VOLUME XIX SEPTEMBER, 1936 NUMBER 9

JOURNAL OF DAIRY SCIENCE

PUBLISHED BY THE
AMERICAN DAIRY SCIENCE ASSOCIATION

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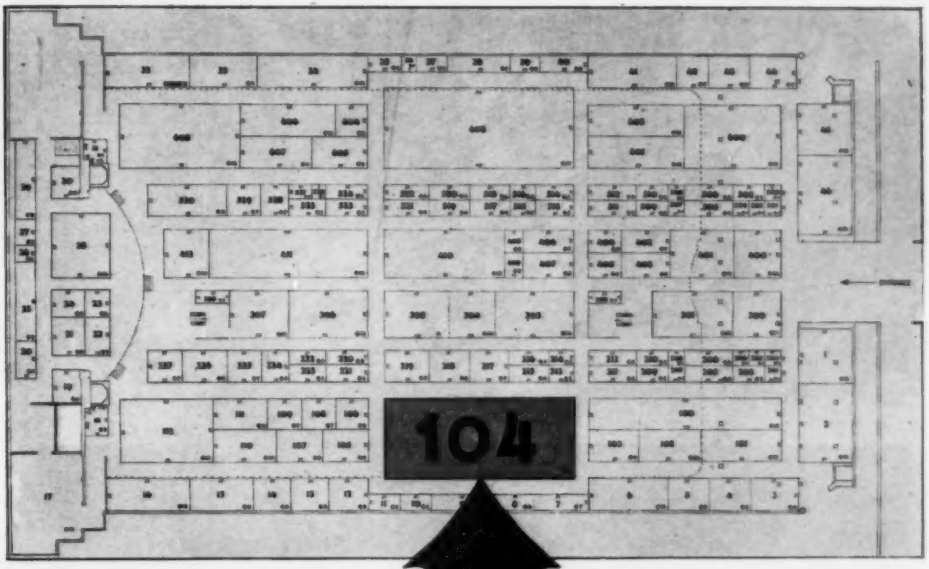

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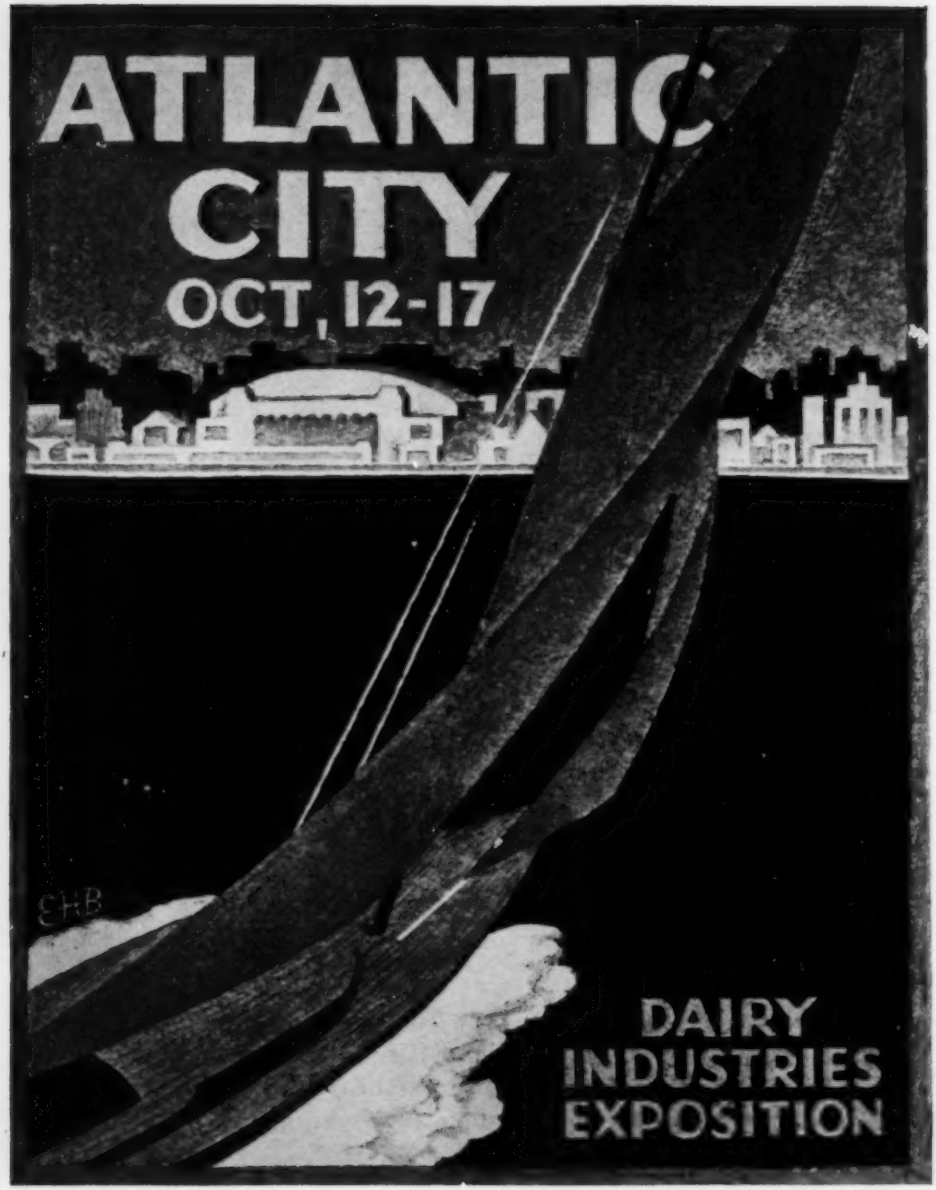

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Manuscripts should be typewritten and carefully revised before submission to A. C. Dahlberg, New York Agricultural Experiment Station, Geneva, New York. Twenty-five reprints will be furnished gratis to authors. Cost of additional reprints and reprint order blank will be submitted with proof.

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JOURNAL OF DAIRY SCIENCE

VOLUME XIX SEPTEMBER, 1936 NUMBER 9

VITAMIN A ACTIVITY OF THIRD CUTTING ALFALFA HAY AS AFFECTED BY METHODS OF CURING*

ELLA WOODS, F. W. ATKESON, HARRY WELLHOUSEN, AND R. F. JOHNSON
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Dairymen universally consider good quality alfalfa hay as the best kind of dry roughage for dairy cows. Choice hay has fine stems, a large percentage of leaves, and is deep green in color. In fact, greenness and percentage of leaves are two important factors in grading alfalfa hay (1). Since good quality hay is higher in protein and minerals and is more palatable to live stock than low quality, curing methods which would produce choice hay have been practiced. This study was made to find what effect curing methods as practiced in Idaho had upon the vitamin A value of alfalfa hay.

Hilton, Hauge, and Wilbur (13) have reported that the vitamin A value of butter responds very rapidly to changes in the vitamin A value of the ration fed to the cows, and that under practical feeding conditions butter with high vitamin A value can be produced in the winter by feeding good quality alfalfa or soy bean hay. Gillam, Heilbron, Morton, Bishop, and Drummond (6) obtained similar results when cows were fed grass silage or dried grass in winter.

Hart and Guilbert (7) have shown that vitamin A deficiency may occur in beef cattle under natural range conditions and suggest that the best practical method of correcting the deficiency is to feed green feed or good quality alfalfa hay.

Meigs and Converse (14, 15) reported that cows fed liberal quantities of good quality alfalfa hay without pasture for several consecutive years maintained their health, milk yield, and reproductive capacity. When timothy hay of mediocre or low quality was fed the milk yield was slightly reduced, health and staying power of the cows was impaired, and decidedly less satisfactory reproduction was obtained than when alfalfa was fed. Calves fed whole milk to 30 days of age and skimmilk thereafter to six months did well when fed No. 1 alfalfa hay, but when fed No. 3 timothy

Received for publication April 2, 1936.

* Published with the approval of the Director as Research Paper No. 139 of the Idaho Agricultural Experiment Station.

hay their growth was dependent on the kind of hay from which the whole milk received in the first 30 days had been produced.

Rogers (22) in reporting the work of the Bureau of Dairy Industry, United States Department of Agriculture, states that their results showed that "all the carotene of alfalfa hay is beta-carotene and that the vitamin A activity of the hay is fully accounted for by its beta-carotene content. . . . This carotene ranges from 9 to 10 gamma per gram of dry matter for timothy hay to from 35 to 100 for good alfalfa hay, or to about 1000 for carrots."

This is in accord with the results obtained by Moore (18) when beta-carotene was compared with a vitamin A concentrate. He concluded from the biological activity of each that carotene is utilized in the body of rats as efficiently as preformed vitamin A at levels approaching the minimum dose. He had previously reported (17) that carotene can be utilized by the dairy cow as vitamin A.

Machines for artificial drying of hay direct from the field are being used to a limited extent in order to obtain higher quality hay, particularly in sections where good weather for field curing is uncertain. Hathaway, Davis, and Graves (9) reported that alfalfa artificially dried in an Arnold drier was twice as potent in vitamin A as high quality, olive green, field cured alfalfa hay. Russell (23) found that alfalfa leaves from plants machine dried by artificial heat contained at least seven times as much vitamin A as the leaves from poor quality field cured hay. Later, Russell, Taylor, and Chichester (24) reported that machine dried alfalfa contained from 2 to 10 times as much vitamin A activity as field cured hay, depending on the length and conditions of exposure in field curing. The carotene content of machine dried alfalfa was not less than that of freshly cut material from the same field. In the field curing process there was a progressive loss of carotene, chiefly during the hours of daylight, amounting to 80 per cent in the first 24 hours.

Hauge and Aitkenhead (11) found that while green color is associated with quality in field cured alfalfa hay, green color is not necessarily an index of vitamin A preservation. Artificial drying at high temperatures was not destructive to vitamin A. They concluded that loss of vitamin A in field cured hay was due to enzyme action rather than to the sun's rays. Machine dried hay did not suffer measurable deterioration in vitamin A after being stored a year.

Smith and Briggs (28) report that compared with the leaves of alfalfa cured in the dark the leaves of alfalfa spread out on the field for 2¾ hours (11:15 A. M. to 2 P. M.) lost from 22 to 33 per cent in vitamin A activity. No greater loss occurred when the hay was left 6¾ hours, but a 75 per cent loss occurred when it was left over night, and an 84 per cent loss when it was left until noon the second day.

Douglass, Tobiska, and Vail (3) found that when cured in diffused light three cuttings of alfalfa hay in three stages of maturity averaged 34.4 rat units of vitamin A activity per gram. Hay cured in the sun averaged 28 units. The following year third cutting hay under the various curing methods had the following vitamin A values: cured in diffused light, 76 rat units; 1.5 inches rain in swath, 18 units; 1 inch rain in cock, 40; 2 inch rain in cock, 38; and moldy hay, 32. Colorado alfalfa hay was higher in vitamin A activity than samples from an eastern and a southern state.

Bethke and Kick (2) reported that the exposing of alfalfa hay to sun, rain, or dew over a period of several days resulted in a marked loss of vitamin A. Sewell and Cottier (25) compared the vitamin A content of kudzu hay cured by three processes: regular field cured, cured in the cock, and cured in the shade. Although the feeding levels were too low to constitute a Sherman unit, the results indicate that the rank of the hay in vitamin A value was shade cured, cock cured, and sun cured.

Hauge (10) found that the vitamin A value of dried young alfalfa, 10 to 12 inches high, was much higher than that of alfalfa in the bloom stage. He also reported that the vitamin A potency of alfalfa hay was located chiefly in the leaves, and the stems were of low vitamin A value. The report of Fraps and associates (4, 5) showed great variation in the vitamin A values for alfalfa hay and alfalfa products. Meigs, Hartman, and Converse (16) reported 35 rat units of vitamin A in No. 1 alfalfa hay, 7 units in No 3 alfalfa, 3 in No. 1 timothy, and 1 in No. 3 timothy.

Hartman (8) bio-assayed one lot of alfalfa hay and two lots of timothy hay purchased in the market and graded according to the official hay standards. Four lots of alfalfa hay taken from the same plot but cured by different methods were also studied. The following relative potencies were obtained: U. S. No. 1 alfalfa, 100; U. S. No. 2 green alfalfa (cured in barn), 100; U. S. No. 2 alfalfa (cured in cocks), 100; U. S. No. 2 alfalfa (sunlight only), 33; U. S. No. 3 alfalfa (sunlight, rain, and dew), 25; U. S. No. 1 timothy, 10; U. S. No. 2 timothy, 3. He also concluded that the vitamin A content of ground or chopped hay decreases with increasing age.

TABLE I

Grades of hay based on official hay standards

SAMPLE NO.	KIND OF ALFALFA HAY	PER CENT STEMS	PER CENT LEAVES	U. S. GRADE
I	Third cutting, swath cured and sweated	47.9	52.1	U. S. No. 1 Extra Leafy
II	Third cutting, cock cured and sweated	34.2	65.8	U. S. No. 1 Extra Green Extra Leafy
III	Third cutting, cock cured, not sweated	47.2	52.8	U. S. No. 1 Extra Green Extra Leafy

DESCRIPTION OF CURING PROCESSES

The hay used was made from Grimm alfalfa grown under irrigation at the Caldwell Substation of the Idaho Agricultural Experiment Station. It was the first year's hay crop, the alfalfa having been seeded without a nurse crop the previous fall. The samples taken represented third cutting hay from the same field, produced under like conditions except for the method of curing. All the hay was mowed the morning of September 26 and received 0.16 of an inch of rain that day. During the curing, the average daily maximum temperature was 77° F. and the average minimum was 35°. The following is a description of each of the three curing processes.

Alfalfa hay No. 1 (swath cured and sweated in the stack). This hay was cured in the swath three days, then raked and cocked, and left in the cock for five days before it was stacked. It was in the swath during the rain and was bleached when stacked. Samples for biological assay were taken November 23, 49 days after the hay was stacked, by removing the top of the stack and taking samples in various places. Hay No. 1 remained in the swath three days and No. II only a little over one day, just long enough to allow it to dry some. The prevailing practice among farmers of the area is to leave alfalfa in the swath about two days before it is cocked.

Alfalfa hay No. III (cock cured and not stacked). This was the same hay as No. II, but the sample was taken from the cock the day before it was stacked. Hay No. II was sampled after going through the "sweating" process in the stack for 49 days. Because of the rather high moisture content of hay No. III, it was air dried in diffused light before grinding.

Each of the samples was graded according to the United States grading standards (1). Since only the pure alfalfa hay was used in feeding, all foreign material was removed before grading. On this basis the sample of hay No. I graded "U. S. No. 1, Extra Leafy," while the sample of hay No. II and of No. III graded "U. S. No. 1, Extra Green, Extra Leafy" (Table I). Hay No. I did not grade "Extra Green" because it had bleached some in the swath. Samples No. I and No. III contained practically the same percentage of leaves (about 52 per cent), while sample No. II contained 66 per cent leaves. Although hay No. III was not analyzed for moisture, its high moisture content was apparent as it was necessary to air dry the sample before grinding in the laboratory.

Table II shows that samples of hay No. I and No. II analyzed practically the same in moisture (7.2 and 7.1). They were slightly lower than the average of 8.6 reported on 250 samples by Henry and Morrison (12). Since some drying probably took place before analysis the exact moisture content of the samples as taken from the stock is not known. Results from the three samples of hay should be comparable as each sample was air dry when fed. Sample No. I, swath cured, was lower in protein and higher in fiber

than sample No. II, but with only one sample of each hay involved the attributing of this difference to the curing process may be questioned. Both samples were considerably higher in protein (No. I, 16.3 per cent and No. II, 18.5) and lower in fiber (No. I, 25.6 and No. II, 22.2) than the average of 14.9 per cent protein and 28.3 per cent fiber reported by Henry and Morrison (12). This would be expected because of the high grade of the hay, which is partially based on percentage of leaves, and leaves are much higher in protein than stems (Table II).

EXPERIMENTAL PROCEDURE

The method used for determining the vitamin A activity of hay was based upon the technique of Sherman and Munsell (26). Young albino rats, 21 to 26 days old and weighing from 31 to 47 grams, were taken from mothers who had received a ration consisting of 30 per cent whole milk powder, 3 per cent powdered egg yolk, 4 per cent wheat germ, 1 per cent iodized salt, and 62 per cent ground whole wheat. The basal vitamin A free diet used consisted of 67 per cent cornstarch, 18 per cent air heated casein, 10 per cent dried yeast powder, 1 per cent sodium chloride, and 4 per cent salt mixture (Osborne and Mendel, 19). The casein was treated according to a modification of Potter's method (21). Vitamin D was furnished by feeding one drop of Mead's Viosterol three times a week.

The usual system of handling the rats in cages prevailed. Each rat was weighed regularly during the depletion period. As soon as there was a cessation of growth or the first sign of ophthalmia appeared, usually accompanied by a tendency to flabby musculature and slightly unkempt fur, the depletion period was ended and the rats were started on the test period with different amounts of hay or hay products as vitamin A supplements. When the hay samples were received at the laboratory sub-samples of whole hay, leaves, and stems were taken and each ground very finely in a laboratory power mill. These sub-samples were stored in closed Economy fruit jars away from heat and light.

Doses were weighed and fed three times a week. Litter mates of essentially the same weight were placed in each of the groups under comparison and in the negative control group. Weekly records were kept of body weight and food consumption, and notes were made on the condition of each rat. The method of eye scoring was that used by Steenbock and Wirick (29). Each rat was autopsied at death or at the end of the eight weeks' test period.

Three series of feeding tests were conducted and will be referred to as the fall series, the winter series, and the spring series. The fall series represented a comparison of the whole hay, leaves, and stems of hay No. III (cock cured and not sweated in the stack). This hay sample, which was the first to arrive at the laboratory, was received October 5. The first rats were

TABLE II

Chemical composition of third cutting alfalfa hay, stems, and leaves

SAMPLE NO.	CURING METHOD	DESCRIPTION	MOISTURE	ASH	CRUDE PROTEIN	CRUDE FAT	CRUDE FIBER	NITROGEN-FREE EXTRACT	CALCIUM	PHOSPHORUS
I	Third cutting, cured in swath and sweated	Whole Alfalfa	7.1	8.9	16.3	1.5	25.6	40.6	1.420	.211
			0	9.5	17.5	1.6	27.6	43.8	1.530	.227
		Stems	7.0	6.8	9.9	1.0	35.5	39.8	.850	.149
			0	7.3	10.7	1.1	38.2	42.7	.915	.160
		Leaves	6.8	13.5	22.3	2.0	12.9	42.5	2.290	.240
			0	14.5	24.0	2.2	13.9	45.4	2.460	.258
II	Third cutting, cured in cock and sweated	Whole Alfalfa	7.2	8.7	18.5	1.9	22.2	41.5	1.590	.209
			0	9.4	19.9	2.2	23.8	44.7	1.710	.225
		Stems	6.9	7.0	12.2	1.1	36.3	36.36	.850	.162
			0	7.6	13.1	1.2	39.0	39.1	.914	.174
		Leaves	7.4	12.5	24.1	2.4	12.0	41.6	2.130	.224
			0	13.5	26.0	2.6	12.9	45.1	2.300	.296

Note: Chemical analyses made by the Department of Agricultural Chemistry, Idaho Agricultural Experiment Station.

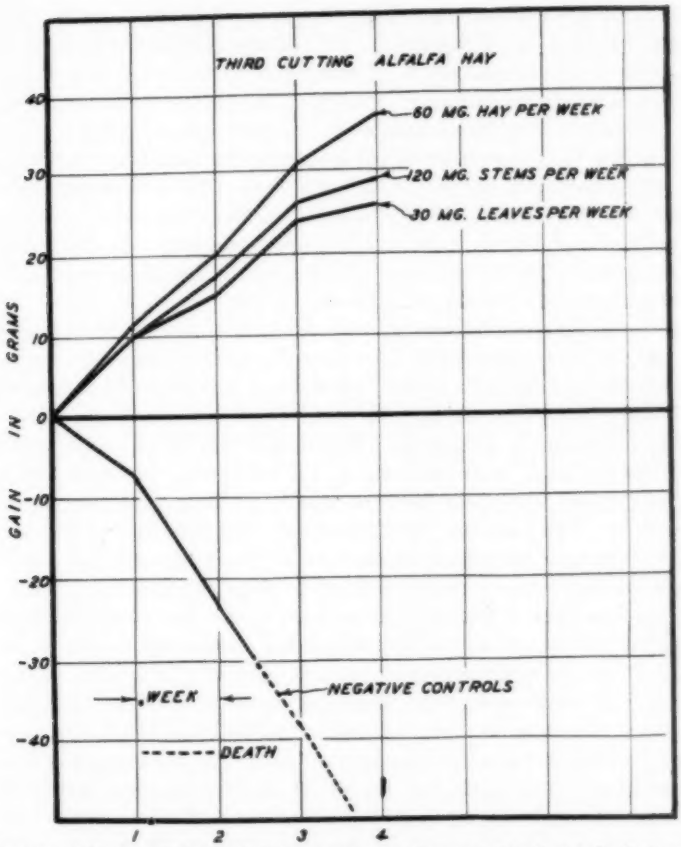

FIG. 1. Average weekly weight increases of rats, previously depleted of vitamin A, when fed either whole hay, stems, or leaves of third cutting alfalfa.

The rat units were calculated from a total average gain of 3 grams per week. Average weekly losses in weight of negative control rats were computed each week by averaging the weight of all living rats as long as 50 per cent of the original group survived. The line was terminated by extending it directly from the last week showing 50 per cent survival to a point indicating the average survival days and average weight at death for the entire group. The broken line indicates that one or more deaths occurred during the week.

started on feed October 6 and the last rats November 7. The test was completed January 3. Thirty-nine rats were divided into four groups as follows: 11 fed 60 milligrams of whole hay per week, 11 fed 120 milligrams of stems, 11 fed 30 milligrams of leaves, and 6 were kept as negative controls.

The winter series represented a similar study of hay No. I (swath cured and sweated in the stack) fed at the same levels as in the fall series. The

sample arrived November 23, and the first rats were started on feed December 14 and the last rats February 5. All the rats completed the eight weeks' test period on or before April 2. These levels were too low to induce gains with hay cured in this manner. Only 2 of the 16 rats represented in the three groups lived the entire eight weeks. At the end of the first four weeks only 3 of the 16 rats were alive and at maximum weight up to date. Another group was then fed whole hay at a level of 90 milligrams per week, a 50 per cent increase, but the level was too low to induce gains. All the rats died before the end of the eight weeks' period, and only two of the six were alive at the end of the fourth week. All the rats in these four groups showed typical symptoms of vitamin A deficiency.

In the spring series of feeding tests whole hay samples of hay numbers I, II, and III were compared to determine the effect of the respective curing processes on the vitamin A acidity. Hay No. I was fed to 10 rats at a level of 120 milligrams per week, hay No. II to 10 rats at 90 milligrams, and hay No. III to 9 rats at 60 milligrams. The doses of hay No. I, swath cured and sweated in the stack, were increased to 120 milligrams per week because in the winter series of feeding tests the level of 90 milligrams was too low to induce gain. The first rats were started on feed February 5 and the last April 7. The test was completed on June 2. The samples of hay No. I and hay No. II had been in the laboratory 74 days when the first rats were started, and sample of hay No. III had been in the laboratory 123 days.

The six groups of rats were quite similar in average weight at the beginning of the depletion period and also at the end (Table III). The average weight of the groups at the beginning varied from 37 to 40 grams, and the average weight at the end of depletion varied from 103 to 116 grams.

The vitamin A values are interpreted from the gains made in the first four weeks although gains for the entire eight weeks are included. In analyzing the results of the first four weeks, the method prescribed for the standardization of cod liver oil by the United States Pharmacopoeia (20) has been considered. The data do not conform in all particulars with these specifications, and there are no results from a group on "Reference oil" so that interpretation can not be made in International Units of Vitamin A. The unit of value used in this paper is the amount which will cause a total average gain of 12 grams in four weeks. Groups of not less than six rats, which represent at least two-thirds of the rats fed, are used in summarizing the results for the 4-week period. For interpretation of the results based on the 8-week period, all animals, even those which died during the test period, are included in the averages.

DISCUSSION OF RESULTS

In 4 of the 6 groups, the coefficient of variation for gains made in four weeks was less than for gains made in eight weeks. Also, the coefficients for

TABLE III

Average growth response of rats when fed third cutting alfalfa hay

SAMPLE NO.	MATERIAL FED	CURING PROCESS	DATES OF TRIALS	AMOUNT PLANT FED WEEKLY	FOUR WEEKS' TEST PERIOD									EIGHT WEEKS' TEST PERIOD					
					RATS FED	RATS USED	RATS USED	AVE. WT. BEGINNING DEPLETION	AVE. WT. BEGINNING TEST PERIOD	AVE. WT. END OF 4 WEEKS	AVE. GAIN IN 4 WEEKS	COEFFICIENT VARIATION	RAT UNITS VITAMIN A	RATS USED	AVE. WT. BEGINNING TEST PERIOD	AVE. WT. END OF 8 WEEKS	AVE. GAIN IN 8 WEEKS	COEFFICIENT VARIATION	RAT UNITS VITAMIN A
					No.	*No.*	*%*	*Grams*	*Grams*	*Grams*	*Grams*	*%*		*No.*	*Grams*	*Grams*	*Grams*	*%*	
A. *Comparison of hay, stems and leaves*																			
III	Hay	Cock Cured, not Sweated	10–7–33	0.060	11	11	100	38	115	152	37 ± 2	20	308 ± 13	11	115	172	57 ± 2	19 ± 3	238 ± 10
III	Stems	Cock Cured, not Sweated	10–7–33	0.120	11	11	100	38	116	145	29 ± 2	28	121 ± 7	11	116	158	42 ± 2	23 ± 3	88 ± 4
III	Leaves	Cock Cured, not Sweated	10–7–33	0.030	11	10	91	39	116	145	29 ± 2	32	483 ± 34	11	115	152	37 ± 4	45 ± 7	308 ± 30
	Negatives		10–7–33			6		43	144	average days survival 24 days average loss in 4 weeks 46 grams									
B. *Comparison of curing methods*																			
I	Hay	Swath Cured and Sweated	3–16–34	0.120	10	9	90	38	105	133	28 ± 2	33	116 ± 9	10	105	138	33 ± 6	76 ± 12	69 ± 12
II	Hay	Cock Cured and Sweated	3–16–34	0.090	10	9	90	40	112	138	26 ± 2	26	144 ± 10	10	110	145	35 ± 6	82 ± 12	97 ± 18
III	Hay	Cock Cured and Sweated	3–16–34	0.060	9	6	67	37	103	131	28 ± 2	29	233 ± 20	10	105	139	34 ± 6	77 ± 12	142 ± 27
	Negatives					9		40	107	average days survival 17 days average loss in 4 weeks 35 grams									

the six groups were more similar at the fourth week, varying from 20 per cent for the lowest to 33 for the highest. The coefficients of variation in these feeding tests were smaller than Sherman and Burtis (27) report may usually be found. The discussion of results will be limited to vitamin A values determined at the end of the first four weeks of each feeding period.

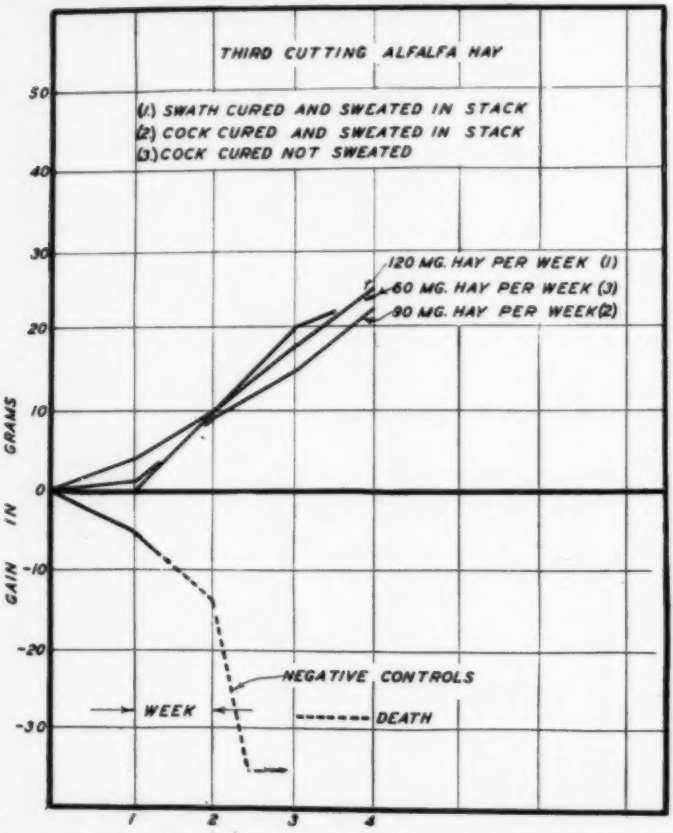

FIG. 2. Average weekly weight increases of rats, previously depleted of vitamin A, when fed third cutting alfalfa hay cured by different methods.

Statistical analysis of the results showed significant differences among the vitamin A values of hay, leaves, and stems, the difference between whole hay and leaves being seven times the probable error of the difference, and between whole hay and stems the difference about 19 times the probable error. The alfalfa hay leaves (483 ± 34 units) contained four times as much vitamin A activity per gram as stems (121 ± 7 units). The grade on

this sample of hay showed 53 per cent leaves and 47 per cent stems. The vitamin A value of the whole hay, computed from the vitamin A value of stems and leaves and the percentage of each, should be 302 rat units. This

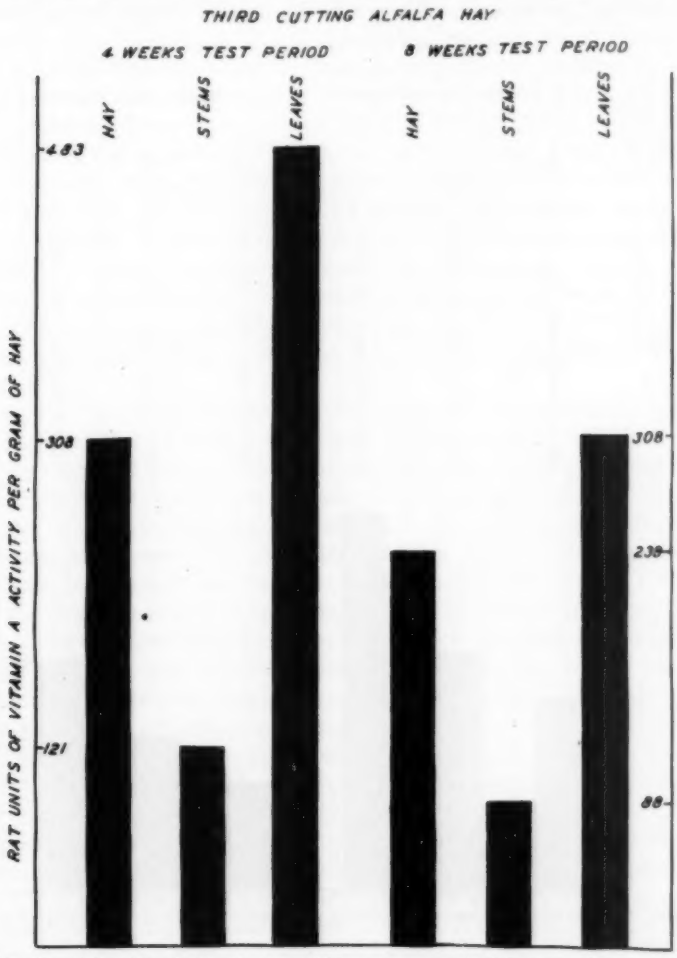

FIG. 3. Rat units of vitamin A activity per gram of whole hay, stems, and leaves of third cutting alfalfa. The rat units were calculated from a total average gain of 3 grams per week. Results are shown for test periods of both 4 and 8 weeks.

is in close agreement with the results found, 308 ± 13 units. In this sample, which was exceptionally high quality hay, about 85 per cent of the vitamin A activity was in the leaves.

When the same whole hay was bio-assayed after being kept in ground form at room temperature and in diffused light for about four months the vitamin A value was 233 ± 20 rat units per gram. This is a reduction of about 24 per cent from the value of 308 ± 13 units obtained soon after har-

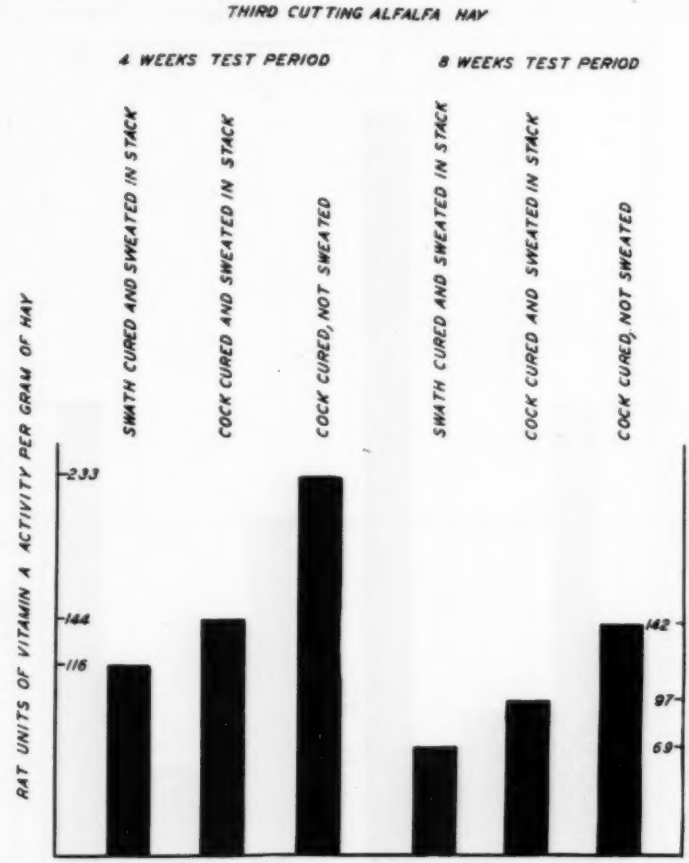

FIG. 4. Rat units of vitamin A activity per gram of third cutting alfalfa hay cured by different methods.

vesting. These results are in agreement with the reports of Hartman (8). Although it would be of practical interest, it is impossible to conclude from this investigation how much loss of vitamin A activity might be expected from storage after hay has gone through the "sweat" and is stored in the stack or bale for various periods of time.

Comparison of swath-curing with cock-curing was made on samples which had been kept in the laboratory for 2½ to 3 months, which probably resulted in lower vitamin A values than would have been obtained on fresher samples. Direct comparison was possible, however, as each hay had been stacked 49 days, the only difference being that hay No. II laid in the swath only one day and curing was completed in the cock, while hay No. I laid in the swath two additional days before being cocked. Hay No. I, which is referred to in this article as swath cured, contained 116 ± 9 rat units of vitamin A activity per gram while hay No. II, cock cured, contained 144 ± 10 units. Thus, the two extra days of exposure in the swath caused a loss of about one-fifth of the vitamin A activity. These results are in harmony with those of Smith and Briggs (28) who found continued loss of vitamin A in alfalfa hay when exposed in the swath from a few hours to one week. Statistical analysis, however, shows that the difference of 28 rat units between swath cured and cock cured hay is not very significant, being only slightly greater than three times the probable error of the difference $(3 \times 9 = 27)$.

Hay that had been sweated, however, showed a significant difference from hay not stacked (both cock cured). The hay which was sweated in the stack contained 144 ± 10 rat units of vitamin A activity per gram, while the hay which was not sweated contained 233 ± 20 units, or a difference of 87 units. This would indicate a reduction of about one-third in vitamin A value due to the sweating process. The probable error of the difference was 15. Thus the difference was about six times the probable error.

In the sweating process considerable heat is generated, and the hay remains damp for some time due to respiration of the plant tissues. These conditions would seem favorable to oxidation and enzyme action, whereas, the hay sampled before stacking was air dried a few days after sampling, which would tend to check enzyme action.

The results of these feeding tests indicate that in order to produce alfalfa hay with high vitamin A value, curing methods which will preserve the green color and prevent shattering of leaves should be used. Fortunately such methods also result in high percentages of protein and minerals and maximum palatability. The official hay standards (1) require that U. S. No. I alfalfa hay shall contain 40 per cent or more of leaves and 60 per cent or more of green color, while U. S. No. II hay shall contain 25 per cent or more of leaves and 35 per cent or more of green color. The fact that two of the samples studied contained 52 per cent of leaves and the other sample 66 per cent and also that two of the three samples graded "extra green" would indicate that the hay fed was of exceptionally high quality. This would account for the high vitamin A values obtained in these feeding tests compared with those obtained in areas where weather conditions are more hazardous for curing. The exceptionally high quality of hay from the

irrigated areas of the western states is generally recognized by livestock men.

Under reasonably good methods, as practiced in these areas, alfalfa hay might be expected to contain 100 or more rat units of vitamin A activity per gram. This would be a potent source of vitamin A for winter feeding of dairy cows and should result in dairy products with high vitamin A values. Fresh green alfalfa samples under pasturage condition has been reported as containing 269 ± 17 rat units per gram (32). Under similar conditions other pasture plants have been found to be high in vitamin A activity (30, 31, 33). Because of the difference in the moisture content of hay and pasture plants as fed, the vitamin A activity per gram of dry matter would be much higher in pasture plants than in alfalfa hay of high quality. Another fact worthy of consideration is that dairy cows normally consume from 3 to 5 times as many pounds of pasture plants daily as they do of alfalfa hay, thereby making the daily intake of vitamin A much greater when the cows are on pasture.

CONCLUSIONS

1. The growth response of rats during a four weeks' feeding period indicated that a fresh sample of third cutting alfalfa hay, cock cured and not sweated in the stack, contained 308 ± 13 rat units of vitamin A activity per gram. Leaves and stems of the same hay contained 483 ± 34 and 121 ± 7 rat units respectively. The leaves contained four times as much vitamin A activity as the stems. About 85 per cent of the vitamin A activity of the hay was in the leaves.

2. Another sample of the same hay was bio-assayed after being kept in ground form at room temperature and in diffused light for about four months. The number of rat units of vitamin A activity found was 233 ± 20, or a reduction, due to storage, of about 24 per cent from the fresher sample of hay, 308 ± 13 units.

3. Comparison of swath curing with cock curing was made with samples 2½ to 3 months old. Third cutting hay cured in the swath three days (swath cured) and then cock cured and sweated in the stack, contained 116 ± 9 rat units of vitamin A activity per gram. The same hay, cured only one day in the swath (cock cured) and then cured in the cock and sweated in the stack, contained 144 ± 10 units. Although one-fifth of the vitamin A activity was lost due to the two additional days curing in the swath, statistically the loss was not very significant.

4. The effect of sweating in the stack on the vitamin A activity of the hay was measured by comparing 2½ to 3 months old hay which was cock cured only with the same hay cock cured and stacked for 49 days. The unsweated hay contained 233 ± 20 rat units of vitamin A activity per gram while the

sweated hay contained 144 ± 10 units, or a reduction of about one-third in the vitamin A units, which was a significant reduction, statistically.

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STUDIES ON THE CHEMICAL COMPOSITION OF THE BLOOD OF DAIRY CATTLE

II. THE EFFECT OF PHOSPHORUS INTAKE ON THE CALCIUM AND INORGANIC PHOSPHORUS CONTENT OF WHOLE BLOOD OF DAIRY HEIFERS DURING THE PERIOD OF FIRST GESTATION AND LACTATION*

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In a former publication (11) observations have been reported on the effect of age and phosphorus intake on the calcium and inorganic phosphorus content of whole blood of dairy heifers during the period of growth. It was shown that low phosphorus rations usually caused an immediate lowering of the inorganic phosphorus in the blood. Frequently the blood inorganic phosphorus continued at a low level until the animals were about eighteen or twenty months of age and then rose to approximately the same level as that of normal animals even though there was no increase in the phosphorus intake in proportion to body weight. As indicated by the inorganic phosphorus of the blood the phosphorus requirement for growth of such animals decreases in proportion to body weight as the animals approach maturity.

Huffman and associates (4) have reported the inorganic phosphorus to be low in the blood of heifers fed a basal ration low in phosphorus from three to eighteen months of age. The inorganic phosphorus in the blood during pregnancy, however, was just as high as was that of heifers fed the basal ration supplemented with steam bone meal. There was, nevertheless, a tendency for the inorganic phosphorus in the blood to be slightly subnormal during the terminal months of pregnancy. Meigs, Blatherwick and Cary (6) observed a drop in the phosphorus content of the blood plasma toward the end of pregnancy, a tendency which they considered to be largely independent of the ration and which shows itself most constantly in the inorganic phosphate fraction. They also observed that the inorganic phosphorus is likely to be low in mature cows just after calving, an observation which has been confirmed by Palmer, Cunningham and Eckles (8) and Wilson and Hart (12).

Robinson and Huffman (9) and Godden and Allcroft (1) (3) found in nearly every case that the inorganic phosphorus of the dam was below that

Received for publication April 9, 1936.

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* Published with the approval of the Director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 164.

of the calf at birth. A short time before parturition there was a lowering of the maternal inorganic phosphorus which returned to normal at about the end of the first week following calving.

Meigs, Blatherwick and Cary (6) found that the phosphatides of plasma show a marked tendency to rise during the first months of lactation and to remain high until lactation has ceased. The rise in the phosphatide of the plasma was found to occur when the animal was on a reduced ration and was likely to be accompanied by a fall in the concentration of inorganic phosphate. They reported this phenomena largely independent of the diet, and that it was thought to be connected with the fact that near the beginning of lactation there is a tendency for the body fat to be released from its stores and thrown out into the blood.

Eckles and associates (2) and Huffman and coworkers (4) have obtained data with animals on phosphorus-deficient rations which show in a very striking manner that the strain of milk production causes a decrease in the inorganic phosphorus of the blood.

Meigs, Blatherwick and Cary (6) obtained results which indicate that in cows the calcium content of the plasma is fairly constant and not affected by either pregnancy or lactation. Robinson and Huffman (9) and Godden and Allcroft (1) (3) found that there was a definite lowering of the serum calcium at or within twenty-four hours of parturition followed by an increase during the first week after calving.

EXPERIMENTAL

For this study grade Holstein heifer calves from one to two weeks of age were purchased from dairymen in the community and divided into two groups. One group was fed a normal ration while the other was fed a ration low in phosphorus. The normal group, consisting of six heifers numbers E 35, E 38, E 39, E 40, E 43 and E 44 was fed a ration composed of timothy hay, corn meal, ground oats, wheat bran, and cottonseed meal or corn gluten meal. The calcium and phosphorus were assumed to be present in sufficient amounts, as the ration is representative of those fed under practical farm conditions without any apparent harmful results.

The low phosphorus group, consisting of eight heifers numbers E 36, E 37, E 41, E 45, E 46, E 48, E 51 and E 58 was fed a ration composed of timothy hay, polished rice, corn gluten meal, and beet pulp or wheat flour. This ration was much lower in its phosphorus content than the ration fed the normal group but otherwise was very similar in its nutritive value as shown by chemical analysis.

The timothy hay used would grade as U. S. No. 1 and was fed at the rate of about 1½ pounds per 100 pounds of live weight per day. The remainder of the digestible crude protein and total digestible nutrients

required to meet the average of the Morrison feeding standard for dairy heifers was supplied by the respective grain rations fed each group.

The feeding and care of the animals, as well as growth measurements and records were very similar to those of previous work (11). During the lactation period the heifers were milked twice daily and an accurate record was kept of all milk and butter-fat produced.

The feeds used were sampled and analyzed as in previous work (11) except that the procedure as described by Morris, Nelson and Palmer (7) for the determination of calcium and phosphorus replaced the A. O. A. C. Methods. The milk was sampled at frequent intervals throughout the lactation period and analyzed for calcium and phosphorus by the A. O. A. C. Methods. Samples of blood were collected from all animals and composite samples were analyzed for calcium and inorganic phosphorus as in previous work (11).

Time of Breeding

The heifers were bred when they were about 18 to 20 months of age. However, breeding difficulties were encountered with the heifers in both groups. Four of the animals in the normal group and one in the low phosphorus group failed to drop calves while on experiment. E 35 showed the first sign of oestrum at 19 months of age and was bred at that time. At 30 months of age she did not show any signs of pregnancy neither had she shown any further signs of oestrum. She was removed from experiment and slaughtered. Post-mortem examination revealed undeveloped sex organs similar to a free-martin. E 39 was bred several times but failed to show any signs of pregnancy at 27 months of age when she was removed from experiment and slaughtered. Nevertheless post-mortem examination revealed the presence of a small foetus. E 40, E 43 and E 51 were bred several times but did not conceive before they were 27 to 30 months of age when they were removed from the experiment as non-breeders.

Effect of Low Phosphorus Intake and Gestation on Blood Composition

In Tables 1 and 2 are presented data showing the calcium and inorganic phosphorus content of the whole blood during first gestation and lactation in 4-week periods. In Table 2 are included determinations of inorganic phosphorus made on the blood of 15 animals in various stages of lactation but not regularly on this experiment. These animals were receiving a normal phosphorus ration and were handled in the same manner as the animals regularly on experiment.

It may be seen in Table 1 that the lower level of phosphorus intake, gestation and lactation were without effect on the calcium content of the blood.

The lower level of phosphorus intake as shown in Table 2 did not have any appreciable effect on the inorganic phosphorus of the blood during gesta-

TABLE 1

Calcium in whole blood during the periods of gestation and lactation

NO. OF ANIMAL	MILLIGRAMS OF CALCIUM IN 100 MILLILITERS OF WHOLE BLOOD																			
	Gestation									Lactation										
	4-week periods before parturition									4-week periods after parturition										
	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	10	11
Low phosphorus ration																				
E 36	7.7	8.3	7.7	8.9	7.3	7.8	8.9	7.4	7.5	7.1	6.7	7.9	7.8	6.9	6.9	7.7	6.8	6.8	9.2	7.9
E 37	*	6.9	7.7	7.2	6.7	8.3	7.3	*	8.1	7.3	7.8	7.7	6.9	6.4	7.8	6.9	6.9	7.6	6.8	6.8
E 41	9.0	7.3	6.3	8.3	7.4	7.8	7.4	6.4	6.3	7.1	7.7	7.8	8.0	7.1	8.4	8.9	7.6	7.6	7.1	7.2
E 45	8.3	6.0	6.9	6.3	6.3	7.4	7.9	7.3	6.5	6.9	7.6	7.4	7.3	8.1	6.5	7.1	6.6	7.4	5.1	
E 46	*	6.4	7.4	6.8	6.9	5.5	7.3	7.4	7.6	6.1	†									
E 48	7.0	7.0	7.0	6.3	6.2	6.9	6.7	7.3	6.7	7.4	6.6	6.8	6.8	**						
Average	8.0	7.0	7.2	7.3	6.8	7.3	7.6	7.2	7.1	7.0	7.3	7.5	7.4	7.1	7.4	7.7	7.0	7.2	7.1	7.3
Normal phosphorus ration																				
E 38	7.1	7.3	6.6	6.2	7.0	6.4	7.9	6.3	8.0	7.6	8.3	7.4	7.1	7.2	7.0	7.8	6.7	8.0	6.7	6.3
E 44	7.2	6.6	6.1	7.5	6.3	7.6	7.1	6.8	6.6	6.7	6.9	7.3	7.8	6.8	6.9	6.7	7.0	6.3		
Average	7.2	7.0	6.4	6.9	6.7	7.0	7.5	6.6	7.3	7.2	7.6	7.4	7.5	7.0	7.0	7.3	6.9	7.2	6.7	6.3

* Sample lost.

** Calcium determinations discontinued.

† Died.

TABLE 2

Inorganic phosphorus in the whole blood during the periods of gestation and lactation

NO. OF ANIMALS	MILLIGRAMS OF INORGANIC PHOSPHORUS IN 100 MILLILITERS OF WHOLE BLOOD																				
	Gestation									Lactation											
	4-week periods before parturition									4-week periods after parturition											
	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	10	11
Low phosphorous ration																					
E 36	5.1	5.6	5.3	5.3	5.9	5.7	5.6	5.6	5.2	4.2	5.2	4.9	4.8	5.0	3.9	3.0	3.2	3.5	5.5	4.5
E 37	*	6.2	5.6	5.8	5.2	4.9	5.3	5.1	4.9	4.6	4.4	5.3	5.7	5.7	5.1	5.1	5.0	4.9	4.7	5.0
E 41	4.8	5.6	6.7	5.8	6.4	5.7	5.5	6.3*	5.5	3.3	4.2	4.9	3.9	3.0	2.9	5.1	4.3	4.6	4.6	4.1
E 45	5.8	6.0	5.6	4.8	5.3	5.0	6.0	4.4	4.9	3.7	3.9	3.7	5.3	5.2	5.1	5.9	5.0	4.8	5.4	
E 46	5.1	5.1	5.4	5.1	4.8	4.8	4.2	4.3	4.1	2.7	††									
E 48	5.1	4.4	4.5	5.1	4.1	5.2	4.5	5.9	4.7	2.9	3.7	2.8	2.9	3.0	3.8	4.9	4.4			
E 58	4.9	5.8	4.5	*	5.1	†														
Average	5.1	5.5	5.4	5.3	5.3	5.2	5.2	5.3	4.9	3.6	4.3	4.3	4.5	4.4	4.2	4.8	4.4	4.5	5.1	4.5
Normal phosphorus ration																					
E 38	5.4	5.2	5.2	5.2	4.7	4.6	4.9	4.9	4.9	4.5	5.4	4.6	5.0	5.0	4.4	4.8	4.9	4.7	4.5	4.0
E 44	6.5	5.7	5.4	5.8	5.3	5.5	4.4	5.0	5.1	4.7	5.5	6.5	5.1	4.6	5.2	4.3	4.8	5.4		
322**																4.2		4.4		
325**										4.2		4.6								
326**															4.6		4.5			
327**														5.3		5.0				
329**															4.3		4.7			
332**												4.9		4.4						
334**																5.5		5.2		
336**										5.0		4.8								
337**											6.0									
347**												6.0		5.7						
349**																5.4				
353**												4.8								
389**										4.3										
390**										5.5										
391**										5.9										
	6.0	5.5	5.3	5.5	5.0	5.1	4.7	5.0	5.0	4.9	5.6	5.2	5.1	5.0	4.6	4.9	4.7	4.9	4.5	4.0

* Sample lost.
** Animals not regularly on this experiment.
† Aborted.
†† Died.

TABLE 3

Body weight; age at parturition; average daily consumption of digestible crude protein, total digestible nutrients, calcium, and phosphorus during period of gestation

NO. OF ANIMALS	BODY WEIGHT			AVERAGE DAILY CONSUMPTION OF—				
	Beginning	End	AGE AT PARTURITION	Digest. protein	Total digest. nutr.	Ca.	P.	P. per 100 pounds of live weight
	lbs.	*lbs.*	*months*	*lbs.*	*lbs.*	*gms.*	*gms.*	*gms.*
Low phosphorus ration								
E 36	900	1300	29	1.58	11.58	22.5	12.7	1.15
E 37	836	1165	27	1.50	11.84	19.3	13.1	1.31
E 41	737	1066	27	1.27	10.04	20.5	11.8	1.31
E 45	780	1025	28	1.28	9.91	19.7	11.5	1.26
E 46	772	1090	26	1.32	9.39	14.6	11.5	1.20
E 48	1104	1339	39	1.21	10.39	20.6	11.8	0.95
E 58	761	*		1.23	9.17	14.6	10.4	1.19
Average	841	1164	29	1.40	10.32	18.8	11.8	1.20
Normal phosphorus ration								
E 38	937	1329	27	1.70	13.37	25.4	32.4	2.85
E 44	873	1094	37	1.22	9.78	15.7	24.3	2.40
Average	905	1212	32	1.46	11.58	20.6	28.4	2.65

* Aborted during fifth month of gestation.

tion. Immediately following parturition there was considerable lowering of the inorganic phosphorus in the blood of the animals in both groups. The lowering was much more pronounced in the case of the animals on the low phosphorus ration.

The blood inorganic phosphorus of the animals on the low phosphorus ration was considerably lower than of the animals receiving the normal

TABLE 4

Body weight; average daily calcium and phosphorus intake; average daily milk; phosphorus in milk; food phosphorus per pound of milk; food phosphorus minus milk phosphorus per 1,000 pounds body weight and inorganic phosphorus in whole blood

4-WEEK PERIODS	BODY WEIGHT	AVER. DAILY INTAKE		AVER. DAILY MILK	AVER. DAILY P. IN MILK	FOOD P. IN MILK	FOOD P. MINUS MILK P. PER 1000 LBS. BODY WEIGHT	INORG. P. IN 100 MLS. BLOOD	REMARKS
		Ca.	P.						
E 36 Low P.	*lbs.*	*gms.*	*gms.*	*lbs.*	*gms.*	*%*	*gms.*	*mgs.*	
1	1106	21.9	16.6	28.8	12.3	74.1	3.9	4.20	
2	1114	25.2	19.5	30.9	13.2	67.7	5.7	5.19	
3	1070	26.8	23.0	35.4	15.1	65.6	7.4	4.85	
4	1056	26.0	22.5	29.2	12.5	55.6	9.5	4.77	
5	1082	25.3	21.4	27.7	11.8	55.1	8.9	5.03	
6	1060	22.7	18.4	25.5	10.9	59.2	7.1	3.89	Deficient
7	1049	23.0	18.1	24.0	10.2	55.7	7.5	2.98	"
8	1052	24.2	19.7	24.1	10.3	52.3	8.9	3.15	"
9	1054	25.6	19.8	24.1	10.3	52.0	9.0	3.50	"
10	1079	25.9	20.6	23.9	10.2	49.5	9.6	5.55	
11	1071	25.6	19.7	21.9	9.3	47.2	9.7	4.53	
12	1066	25.3	19.2	22.0	9.4	48.9	9.2	4.47	
E 37 Low P.									
1	1004	18.5	13.8	21.6	9.2	66.8	4.6	4.63	
2	996	19.9	16.5	24.5	10.4	63.0	6.1	4.38	
3	991	18.0	16.4	22.9	9.8	59.7	6.7	4.58	
4	967	16.4	16.4	20.5	8.7	53.1	8.0	5.70	
5	940	18.5	18.3	22.3	9.5	51.9	9.4	5.73	
6	934	18.1	18.2	20.8	8.9	48.9	10.0	5.12	
7	939	18.0	17.5	18.5	7.9	45.2	10.2	5.10	
8	942	17.9	17.1	17.2	7.3	42.7	10.4		
9	948	18.0	16.4	17.9	7.6	46.3	9.3	5.00	
10	907	18.1	15.8	16.0	6.8	43.0	9.9	4.92	
11	951	17.6	15.9	15.0	6.4	40.2	10.0	4.65	
12	933	17.6	15.6	14.5	6.2	39.7	10.1	5.00	
E 41 Low P.									
1	935	21.2	13.7	24.5	10.4	75.9	3.5	3.33	
2	874	20.0	15.7	22.5	10.9	69.4	5.5	4.20	
3	855	20.2	16.8	22.9	9.8	58.3	8.2	4.86	
4	837	19.7	16.2	20.1	8.6	53.1	9.1	3.87	Deficient
5	837	20.5	15.9	19.9	8.5	53.4	8.8	3.03	"
6	879	20.5	15.7	19.5	8.3	52.8	8.4	2.88	"
7	862	21.2	16.1	16.7	7.1	44.1	10.4	5.12	
8	868	20.1	14.6	14.6	6.2	42.5	9.7	4.29	
9	871	19.7	14.1	12.4	5.3	37.6	10.1	4.64	
10	894	19.3	14.3	9.7	4.1	28.6	11.4	4.55	

TABLE 4—(*Continued*)

4-WEEK PERIODS	BODY WEIGHT	AVER. DAILY INTAKE		AVER. DAILY MILK	AVER. DAILY P. IN MILK	FOOD P. IN MILK	FOOD P. MINUS MILK P. PER 1000 LBS. BODY WEIGHT	INORG. P. IN 100 MLS. BLOOD	REMARKS
		Ca.	P.						
E 45 Low P.	*lbs.*	*gms.*	*gms.*	*lbs.*	*gms.*	%	*gms.*	*mgs.*	
1	920	25.6	15.0	18.4	7.8	52.0	7.8	3.74	Deficient
2	917	27.0	16.6	23.9	10.2	61.5	7.0	3.87	"
3	896	25.3	16.4	22.7	9.7	59.1	8.6	3.69	"
3½	858	26.6	16.9	21.7	9.3	55.0	8.9		
Changed to Normal Phosphorus Ration									
4		24.9	50.3	20.8	8.9	17.7		5.31	
5	868	25.3	51.3	22.5	9.6	18.7	48.0	5.24	
6	847	25.7	52.8	20.5	8.7	16.5	52.1	5.06	
7	856	25.2	51.6	15.2	6.5	12.6	52.7	5.91	
8	870	24.9	49.9	15.5	6.6	13.2	49.8	4.97	
9	895	23.0	33.8	15.1	6.4	18.9	30.6	4.77	
10	893	23.4	33.8	13.7	5.8	17.2	30.5	5.36	
E 48 Low P.									
1	1137	24.3	14.2	25.1	10.7	75.4	3.1	2.91	Deficient
2	1094	26.1	15.7	29.9	12.8	81.5	2.7	3.71	"
3	1080	25.9	15.9	27.5	11.7	73.5	3.9	2.78	"
4	1046	25.6	16.5	27.3	11.6	70.3	4.7	2.93	"
5	1048	25.1	15.8	24.9	10.6	67.1	5.0	2.97	"
6	1003	24.8	13.8	21.3	9.1	65.9	4.7	3.84	"
7	1023	24.8	15.7	20.0	8.5	54.1	7.0	4.86	
8	1008	24.7	15.5	18.9	8.1	52.3	7.3	4.35	

ration and was subject to much greater fluctuations throughout the lactation period.

Data are presented in Table 3 showing the body weight and the age at parturition for the animals in both groups. The average daily consumption of digestible crude protein, total digestible nutrients, calcium and phosphorus and the phosphorus per 100 pounds of body weight of the animals during the period of gestation are also presented in Table 3.

It is shown in Table 3 that an average daily intake of 11.8 grams (equivalent to 1.2 grams per 100 pounds of body weight) of phosphorus met the requirement for phosphorus as indicated by the inorganic phosphorus of the whole blood of the heifers during the period of first gestation.

Effect of Low Phosphorus Intake and Milk Production on Blood Composition

Data are presented in Table 4 showing the body weight, average daily calcium and phosphorus intake, average daily milk production, phosphorus in the milk, percentage of food phosphorus in the milk, food phosphorus minus the milk phosphorus per 1000 pounds body weight, and the inorganic phosphorus in the blood for the low phosphorus animals during lactation.

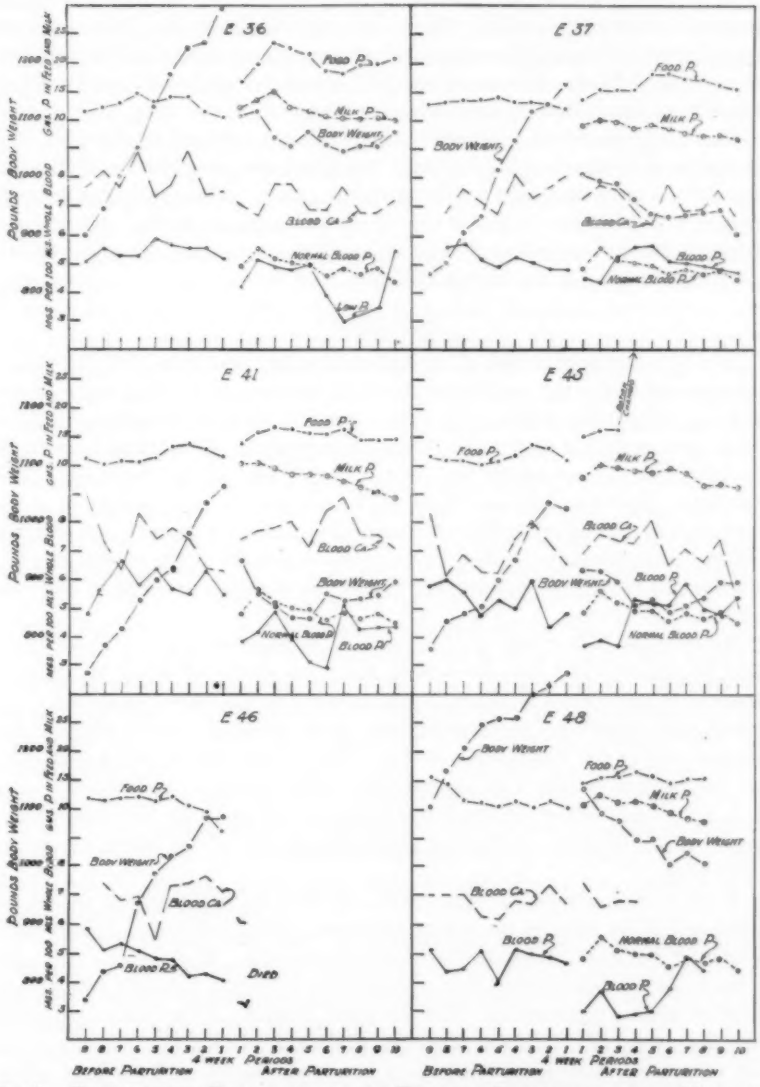

FIG. 1. EFFECT OF THE PHOSPHORUS IN THE FEED, THE PHOSPHORUS IN THE MILK AND THE CHANGE IN BODY WEIGHT ON THE CALCIUM AND INORGANIC PHOSPHORUS CONTENT OF WHOLE BLOOD.

The lower level of phosphorus intake was without effect on the phosphorus content of the milk. The numerical values for the percentage of phosphorus in the samples analyzed were maximum 0.1050, minimum 0.0874, and average 0.0944. The mean value of 0.0944 per cent was used in calculating the average daily phosphorus in the milk.

Figure 1 shows the changes in body weight, phosphorus intake, and calcium and inorganic phosphorus in the blood during gestation and lactation for the animals on the low phosphorus ration. The average values for inorganic phosphorus in the blood of normal animals during lactation as shown in Table 2 are repeated in the figure for comparison. The phosphorus in the milk during lactation is also shown.

DISCUSSION

The physical appearance of the heifers and the data presented in Table 3 indicate that under the conditions of this experiment an average daily intake of 11.8 grams, equivalent to 1.2 grams per 100 pounds of body weight, of phosphorus was sufficient to maintain the inorganic phosphorus content of the blood at approximately the normal level during the period of first gestation. Huffman and associates (4) found that 10 to 12 grams of phosphorus daily furnished sufficient phosphorus for maintenance and growth and for the development of the foetus from 18 months of age to first calving as indicated by the blood phosphorus and the strength and size of the calf at birth.

An average daily intake of 11.8 grams of phosphorus as fed in this experiment apparently did not allow very much in excess of what is actually required to maintain the inorganic phosphorus in the blood, since the drop immediately following parturition was much greater in the case of the animals on the low phosphorus ration. There was also a strong tendency for the heifers on the low phosphorus ration to show anorexia, or loss of appetite and other physical symptoms of phosphorus deficiency associated with a decrease in the inorganic phosphorus of the blood following parturition.

E 58, on the low phosphorus ration, aborted during the fifth month of gestation. E 46, also on the low phosphorus ration, refused a considerable portion of her feed during the last half of gestation. There was a decrease in the inorganic phosphorus of her blood from 5.1 to 4.1 mgs. per 100 mls. of blood preceding parturition. She dropped a dead calf at the end of 270 days' gestation. The calf was presented abnormally and had to be taken. It was very small but appeared normal in conformation. Two days after calving the placenta had to be removed. On the third day after calving the rear quarters of the udder gave bloody milk, but this cleared up in about three days. After calving E 46 continued to refuse a considerable portion of the feed offered and there was also loss in body weight. Her condition

grew worse and about 18 days after calving she was unable to get up. Six samples of blood taken on alternate days following parturition averaged 2.8 mgs. of inorganic phosphorus and 6.4 mgs. of calcium per 100 mls. of whole blood. A sample of blood taken the day before the animal died contained 2.4 mgs. of inorganic phosphorus and 5.4 mgs. of calcium per 100 mls. of blood. There was some indication that the calcium was slightly reduced below normal following parturition. The heifer died on the twentieth day after calving following an injection of about 200 mls. of a 10 per cent solution of calcium gluconate.

The inorganic phosphorus in the blood of the animals on the normal phosphorus ration showed an increase from the first to the second 4-week period following parturition. After the second period following parturition there was a slight decline in the inorganic phosphorus of the blood as lactation progressed. The results obtained with the animals on the low phosphorus ration were rather variable as shown in Figure 1 and Table 4. The data presented show that milk production combined with low phosphorus intake has a considerable effect on the inorganic phosphorus content of the blood. The effect of these two factors is particularly striking in the case of cow E 48, where the excess of feed phosphorus over the milk phosphorus was small, and in E 45, where the ration was changed. It is also shown to some extent in cows E 36 and E 41, but not to any appreciable extent in the case of E 37, where the excess of food phosphorus over the milk phosphorus was too large to produce any very striking results.

It is interesting to note in the case of cows E 36 and E 41 that the phosphorus consumed in the feed in excess of that excreted in the milk was less during the first part of lactation, when the inorganic phosphorus in the blood was about normal, than during the latter part of lactation, when the blood phosphorus showed a deficiency. This may be associated with a removal of phosphorus from the body stores during the early part of lactation. The animals all showed considerable loss in body weight during the first part of lactation and usually small gains during the latter part. There was always a decrease in the percentage of food phosphorus excreted in the milk as lactation progressed.

The data indicate that under the conditions of this experiment about 9 to 10 grams of phosphorus per 1000 pounds of body weight was required in the feed in excess of that excreted in the milk to maintain the inorganic phosphorus in the blood at the normal level.

Rose (10) reported that for maintenance of phosphorus equilibrium the requirement would seem to be the amount of phosphorus eliminated in the milk plus 26 mgs. per kilo body weight (equivalent to 11.8 grams per 1000 pounds body weight.) An excess over this amount caused phosphorus retention, and smaller quantities resulted in loss of phosphorus from the animal.

Ten grams of phosphorus per 1000 pounds of body weight for maintenance as determined by Henneberg and used by Kellner (5) and Huffman and associates (4) compares favorably with the amount found in the present investigation to be required in the feed in excess of that in the milk in order to maintain the inorganic phosphorus of the blood.

Huffman and associates (4) found that the phosphorus requirement for milk production ranged from 0.5 to 0.7 gram of food phosphorus per pound of milk, above maintenance. Ten grams of phosphorus per 1000 pounds of live weight was used for maintenance.

In the present investigation when 10 grams of phosphorus per 1000 pounds of body weight was allowed for maintenance, about 0.4 to 0.5 gram of phosphorus per pound of milk was required to maintain the inorganic phosphorus in the blood. It should be noted that the animals used in this experiment were not heavy milkers, producing only 20 to 30 pounds of milk per day at the peak of production. It is interesting to note also, that in the case of E 45 (Table 4), when the animal was changed from the low phosphorus ration to the normal phosphorus ration, the inorganic phosphorus in the blood rose to the normal level, but there was no increase in the milk produced.

SUMMARY AND CONCLUSIONS

The calcium and inorganic phosphorus content of the whole blood of two groups of Holstein heifers has been studied during the periods of gestation and first lactation. One group was fed a normal phosphorus ration while the other was fed a ration low in phosphorus. Both groups received approximately the same amount of digestible crude protein and total digestible nutrients in proportion to body weight and the amount of milk produced.

From the results obtained under the conditions of the experiment outlined the following conclusions were reached.

1. An average daily intake of 11.8 grams of phosphorus (equivalent to 1.2 grams per 100 pounds of body weight) was sufficient to maintain the inorganic phosphorus in the blood at approximately the normal level during the period of first gestation.

2. There was a decided drop in the inorganic phosphorus of the blood at or immediately following parturition, which was much more pronounced in the case of the animals on the low phosphorus ration.

3. Milk production combined with low phosphorus intake caused a lowering of the inorganic phosphorus content of the blood.

4. The phosphorus in the feed should exceed the phosphorus in the milk by 9 to 10 grams per 1000 pounds body weight in order to maintain the inorganic phosphorus content of the blood for Holstein heifers producing 20 to 30 pounds of milk per day.

5. The lower level of phosphorus intake, gestation, and lactation had no appreciable effect on the calcium content of whole blood.

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ALFALFA SILAGE

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The desirability of a satisfactory method for preserving alfalfa as silage has long been recognized. Because of the fact that only a part of the attempts to obtain a good grade of silage from alfalfa have been successful, the studies described in this paper were undertaken with the object of trying to solve some of the difficulties involved in the problem. The present paper is a preliminary report of studies now in progress.

HISTORICAL

Many reports of experiments with alfalfa and other legumes as silage crops appear in the literature, but only those which seem to have a direct bearing on the studies reported in this paper are mentioned in this brief review.

Trials have been reported (10, 11, 12, and 13) in which it was found that good quality silage was produced from alfalfa only, while other reports (8 and 14) state that great losses or complete failures occurred when alfalfa was ensiled alone. Allowing the alfalfa to wilt before ensiling was found successful by several investigators (3, 4, 10, and 12), while others (1 and 13) point out that it should be ensiled before it has wilted much. It is stated in several reports (1, 2, 5, 6, 11, and 12) that mixing molasses with the alfalfa as it is ensiled proves effective in increasing either or both the palatability and keeping qualities of the silage. Another report (9) describes successful results with mineral acids as preservatives. Mixing green alfalfa with freshly-harvested sugar-containing crops such as corn, sorghum, kafir, green rye, and mixing with corn meal have also been reported (6, 11, and 12) as effective methods of making good silage. Investigations (7 and 8) of the kinds and amounts of acid present in alfalfa silage led to the conclusion that the acid fermentation of alfalfa silage is dissimilar to that of corn silage and that alfalfa silage is unfit for feeding unless fed soon after ensiling.

EXPERIMENTAL METHODS

Series A.—Cylindrical, galvanized-iron cans about 9 inches in diameter and 27 inches deep were used as silos. The capacity of each was about 37 pounds of chopped alfalfa. The alfalfa consisted of young, new growth crop following three harvests earlier in the season. There was a very small admixture of weeds. It was harvested with a field mower on September 10, 1935, taken from the field at once, and chopped into short lengths by a

Received for publication April 17, 1936.

power cutter. The corn which was mixed with the alfalfa in filling two of the silos was at an early stage of development for silage purposes. It also was chopped. Random samples of both crops were taken for analysis.

TABLE 1

Effect of the addition of preservatives to alfalfa at time of ensiling on keeping qualities and acidity of the silage

SILO NO.	PRESERVATIVES ADDED AT TIME OF ENSILING	DRY MATTER IN ALFALFA AS ENSILED	DRY MATTER IN SILAGE AS REMOVED	RECOVERY OF GOOD SILAGE[1]	ACID CONTENT OF SILAGE	
					Fresh basis[2]	Dry matter basis[3]
		per cent	*per cent*	*per cent*	*per cent*	*per cent*
		Series A				
2	None	25	24	77	1.11	4.63
3	Whey powder, 1 per cent	25	25	75	1.36	5.44
4	Whey powder, 2 per cent	25	26	74	1.66	6.38
5	Whey powder, 3 per cent	25	26	79	1.81	6.96
6	Whey powder, 4 per cent	25	26	77	1.71	6.58
7	Whey powder, 5 per cent	25	27	76	1.91	7.07
8	Alfalfa ½, chopped corn ½	24[4]	24	75	1.61	6.71
9	Alfalfa ⅔, chopped corn ⅓	24[4]	24	77	1.66	6.92
10	None	32	32	76	1.16	3.63
11	Molasses, 1 per cent	32	31	74	1.21	3.90
12	Molasses, 2 per cent	32	32	71	1.26	3.94
13	Molasses, 3 per cent	32	33	71	1.17	3.55
14	Molasses, 4 per cent	32	33	70	1.41	4.27
15	Molasses, 5 per cent	32	33	75	1.54	4.67
		Series B				
16	Water, 3 per cent	23	23	73	1.11	4.83
17	Water, 2 per cent, lactic acid starter, 1 per cent	23	23	73	1.46	6.35
18	Water, 1 per cent, lactic acid starter, 3 per cent	23	23	74	1.41	6.13
19	Water, 2 per cent, Bulgarlac 1 per cent	23	23	68	1.26	5.48
20	Water, 1 per cent, Bulgarlac 3 per cent	23	23	77	1.31	5.70
		Series C				
21	Water, 5 per cent	27	24	59	.96	4.00
22	Water, 4.25 per cent, molasses .75 per cent	27	23	60	1.00	4.35
23	Water, 3.5 per cent, molasses 1.5 per cent	27	25	71	.88	3.52
24	Water, 2 per cent, molasses 3.0 per cent	27	28	54	1.11	3.96
		Series D				
25	Water, 1.5 per cent, molasses, 3 per cent	39	39	70	1.45	3.72
26	Water, 3 per cent, molasses, 1.5 per cent	39	36	80	1.32	3.67
27	Water, 4.5 per cent	39	35	83	1.31	3.74

[1] In percentage of weight of crop as ensiled plus any water or preservatives added.

[2] In terms of cc. 0.1 N NaOH per gram of silage, fresh basis.

[3] In terms of cc. 0.1 N NaOH per gram of dry matter in silage.

[4] Dry matter in alfalfa 24.7 per cent, in corn 23.7 per cent.

Whey dried to a powder and blackstrap cane feeding molasses (61 per cent dry matter) were used as sources of fermentible sugars for preservation by produced acids (table 1). Mixing of weighed amounts was done by hand in a large metal tub. The silos were filled by hand while a helper tamped the material solid. Coverings consisted of a layer of slater's felt, and circular boards which fitted loosely inside the silos. Bricks were added to provide a weight of about 25 pounds to the square foot.

Series B.—Galvanized-iron garbage cans having a capacity of about 75 pounds cut alfalfa were used as silos. The alfalfa which was harvested October 3, 1935, was more mature than that used in Series A, and was admixed with about 21 per cent weeds, mostly crab grass. Cutting was done with a power cutter. Random samples of the cut material were taken for analysis. Filling was done by hand, the preservatives being sprinkled over the cut material as it was placed in the silos. The material was compacted by tramping. The preservatives used were lactic acid starter and Bulgarlac culture,[1] both prepared fresh for the purpose and incubated at proper temperatures until used. Coverings consisted of slater's felt, circular board covers, and sacks of agricultural limestone sufficient to provide a total weight of covering equivalent to approximately 25 pounds to the square foot.

Series C.—Equipment, materials and procedure were the same in this series as in Series B, with two exceptions. The alfalfa was ensiled unchopped, that is, it was ensiled "whole" just as harvested with a field mower, and different preservatives were used than in Series B. The amount of alfalfa placed in each silo was 65 pounds. It could not be compacted as closely as the chopped alfalfa.

Series D.—The silos used in this series consisted of wood stave tanks 4 feet in diameter and 10 feet deep. Materials, methods, time of filling, etc., were the same as in Series B, except that different preservatives were used and these were thoroughly mixed with the cut alfalfa by means of shovels before the material was ensiled. From 700 to 1,000 pounds of cut alfalfa were placed in each silo.

General Procedure.—All the silos (Series A, B, C and D) were stored in a barn. Those used in Series B and C were surrounded with shavings to reduce heat losses.

The silos in Series A, B, and C were opened December 21, 1935, and the silage weighed and sampled. The three silos of Series D were opened January 9, 1936, January 18, 1936, and February 12, 1936, respectively. The spoiled silage was removed from each silo by hand and decision as to the dividing line between spoiled and good silage was made by the aid of visual estimates and odor only. The silage in the three silos of Series D was fed to two Holstein cows, one producing upwards of 30 pounds milk daily and

[1] A skim milk culture of *B. bulgaricus.*

the other more than 50 pounds daily. Alfalfa silage was substituted gradually for corn silage in the rations of the two cows until the level of feeding reached 25 to 30 pounds of alfalfa silage daily.

The procedure for determination of water-soluble acidity outlined by the Association of Official Agricultural Chemists was followed except for certain modifications. The method used follows: To a 100-gram sample of silage, 500 cc. of freshly boiled distilled water and 1 cc. formalin solution were added. The stoppered flasks were shaken for 15 minutes on a shaking machine. After filtering, 50 cc. of the filtrate were made up to 500 cc. in a graduated flask. A 100 cc. portion, equivalent to 2 grams of sample, was titrated with 0.1 N NaOH, using phenolphthalein indicator.

DISCUSSION OF RESULTS

Series A.—All of the alfalfa ensiled in Series A produced silage having a pungent acid odor, pleasant aroma and dark green color. But little difference in these qualities could be detected in the fourteen lots of silage in this series. The recovery of good silage from the various silos (Table 1) showed no significant differences and hence no advantages in this respect for the addition of the preservatives. The use of the whey powder and molasses apparently caused an increase in acid content of the silage and presumably this would be a desirable factor in silage which is to be kept over a long period, particularly during hot weather. A higher acid content was produced with the larger amounts of preservative but the determinations did not show a uniform increase.

Small amounts of silage from a number of silos in Series A were eaten eagerly by cows not fed alfalfa silage previously.

Series B.—The silage removed from the silos of Series B was similar to that in Series A in percentage recovery and qualities of the silage. The use of the lactic acid and Bulgarlac cultures evidently caused an increase in acid content but no relation between amounts of preservatives added and the acid content of the silage was found.

Series C.—The whole (unchopped) alfalfa ensiled in this series of experiments did not keep quite as well as the chopped alfalfa in the other series. This was attributed to the difficulty experienced in packing the whole alfalfa closely to the corrugated sides of the silos. Some mold was found next to the walls below the line of demarcation of the spoiled surface layer. The silage in the centers of the silos appeared excellent, however. It is reasonable to assume, upon the basis of the results obtained, that whole alfalfa properly packed in a suitable container will make silage of good quality.

No definite conclusions with regard to the use of molasses as a preservative can be drawn from this series of experiments on account of the poorer keeping conditions of the silage.

Series D.—The silage in this series of experiments was not as green in color as that in the other series and resembled dampened hay. It is assumed on the basis of appearance, keeping quality and palatibility that the dry matter content of this lot of alfalfa at the time of ensiling, namely 39 per cent, is about the upper limit at which alfalfa ensiled without preservatives will keep satisfactorily.

The mixing of molasses with the alfalfa at the time of ensiling produced a more palatable silage than the ensiling of alfalfa alone, as judged by feeding tests with the silage from each of the three silos in this series. The silage from Silos 25 and 26, in which molasses was used at the rates of 3 per cent and 1.5 per cent, respectively, of the weights of the alfalfa, was eaten with great relish, but that from Silo 27 to which no preservative other than water was added was not eaten as readily.

Alfalfa silage was gradually substituted for corn silage during one week and the cows were then fed alfalfa silage (together with alfalfa hay and a grain mixture) continuously for approximately six weeks. Comparison of the production during the two weeks preceding and the two weeks following the alfalfa silage feeding failed to reveal any noticeable effect of the alfalfa silage feeding upon productivity of the cows (Table 2).

TABLE 2

Production of Holstein cows fed alfalfa silage

WEEK ENDING (1936)	YIELD OF FAT-CORRECTED MILK (F.C.M.)[1]	
	Cow 446	Cow 553
	pounds	*pounds*
Preliminary period-corn silage		
January 3	350	250
" 10	347	242
Alfalfa silage period		
January 17	373	249
" 24	375	247
" 31	353	245
February 7	335	249
" 14	334	232
" 21	331	219
" 28	338	236
Subsequent period-corn silage		
March 6	303	208
" 13	320	205

[1] Milk yield corrected to an energy equivalent basis of 4 per cent milk by application of the Gaines formula: F. C. M. = 0.4 × milk in pounds + 15 × fat in pounds.

The feeding of alfalfa silage induced a very laxative condition in the two cows, leading to the conclusion that alfalfa silage is more laxative in its

effects than corn silage, although no measurements of the softness of the feces were made.

SUMMARY AND CONCLUSIONS

Alfalfa was ensiled in twenty-three small metal silos and three wooden tanks. It was found that small cylindrical metal containers may be used satisfactorily in experimental studies of silage.

Whey powder mixed with the alfalfa at the time of ensiling at the rates of 1, 2, 3, 4, and 5 per cent, respectively, of the weights of the alfalfa caused an increase in the acid content of the silage over that of alfalfa ensiled alone, and in most cases the larger amounts of powder produced a more acid silage. Blackstrap cane feeding molasses, lactic acid starter, and Bulgarlac culture incorporated with the alfalfa at the time of ensiling also caused some increases in the acidity of the silage. The whey powder seemed to be the most effective of the preservatives used in causing an increase in the acid content.

A good quality of silage resulted from the mixing of chopped green corn harvested at an early silage stage with chopped alfalfa.

Alfalfa ensiled whole (unchopped) did not keep as well as chopped alfalfa, but it is believed that when ensiled under suitable conditions, whole alfalfa may readily be preserved as silage.

Different lots of alfalfa having dry matter contents at the time of ensiling of 23 per cent, 25 per cent, 27 per cent, 32 per cent, and 39 per cent, respectively, which were ensiled without preservatives except for a very small amount of water, yielded silage having good keeping qualities. It is concluded on the basis of these trials that a dry matter content of 39 per cent is about the upper limit for the successful ensiling of alfalfa alone.

Alfalfa silage is a very palatable feed for dairy cows and when fed in limited amounts has a feeding value comparable with that of corn silage, but has a laxative effect greater than that of corn silage.

ACKNOWLEDGEMENT

The authors are indebted to Dr. H. A. Ruehe, Head of the Department for suggestions in carrying out the project, and to Dr. O. R. Overman, in whose laboratory the acidity determinations were made, for suggesting suitable modifications in the method of determining acidity.

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SEASONAL VARIATION IN THE BIRTH RATE OF THE MILKING GOAT IN THE UNITED STATES*

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Normal sexually mature non-pregnant dairy cows pass through regular estrus cycles throughout all seasons of the year. It is possible, therefore, to breed cows to calve whenever desired. This is a very desirable characteristic of cattle, as it makes possible the production of a fairly uniform milk supply or permits breeding cows for fall calving where that practice is indicated.

The dairy goat, in common with most breeds of sheep, appears to differ in this respect from cattle. Shaw (4) reported from observations of the goat herd of the U. S. Department of Agriculture that does come into heat at all times of the year, but not frequently between the first of March and the middle of August.

In an extensive study of the season of conception of milk goats in Great Britain, Asdell (1) observed a gradual increase in the rate of conception from August to October, followed by a gradual decline reaching a minimum in May. The number of conceptions during the four months, April May, June and July was very small. Evidence was presented suggesting that a cool summer produced early estrus while a hot summer had the opposite effect.

Kupfer (3) studied the periodicity of the ovarian changes of the goat both in Switzerland and in South Africa. In Europe ovulation was definitely observed during the months of October, November and December. The season was believed to extend into adjoining months under certain circumstances. Ovulation was reported to recur at regular three weeks' intervals. There then follows a period of reduced ovarian activity. Ovulation is entirely suppressed during this time. It was emphasized that in the sexual functions of the goat a long period of rest alternates with a period of ovarian activity.

Observations were also reported upon the Boer goat of South Africa. These goats also were seasonal breeders. The season of ovarian activity probably extends from April to August during the winter with ovulations at intervals of about three weeks. In the spring and summer, from September to February, or March ovulations are held in abeyance.

The sexual activity of goats in the Philippine Islands has been studied by Villegas (5). The month of conception and of parturition in 103 mat-

Received for publication April 22, 1936.

*Contribution from the Department of Dairy Husbandry, Missouri Agricultural Experiment Station Journal Series No. 463.

ings were tabulated. Two sexual seasons were observed, the first during May and June and the second in November. Over 30 per cent of the matings occurred in the two spring months and over 40 per cent in the four months from November to February. It is interesting to note that sheep had practically the same sexual and reproductive seasons as goats.

These studies indicate considerable variation in the sexual activity of dairy goats in various countries under varying climatic conditions. Due to an interest in the goat as an experimental animal in connection with studies concerned with the hormone control of milk secretion, it became of interest to learn more of the reproductive process in this animal.

The object of the present paper is to report the results of a study to determine the duration of the fertile season in the goat under conditions in the United States. Through the kindness of Dr. A. J. Durant, of the Department of Veterinary Science of the Missouri College of Agriculture, a file of the American Milk Goat Record Association containing the date of the birth of over 37,000 animals of the several breeds of milk goats was made available for study.

The number of births occurring during the various seasons of the year was determined by grouping the records according to the date of birth of the kids. It is a record of births rather than the number of does which parturated. The months were divided into two parts, 1 to 15 and 16 to 29, 30 or 31 depending on the length of the month. These data show that the does begin to kid in January, about 5 per cent of the total population kidding in the month (Table 1). The number rapidly increases in February and during the first half of March. From that time the number of births gradually declines each month until July when about 3 per cent kidded. From August until December the number of goats kidding is negligible. From January to June over 93 per cent of the goats recorded were born. These data clearly indicate that the milk goats raised in the United States are distinctly seasonal breeders. Included in the group are goats of four breeds, the Toggenburg, the Saanen, the Nubian, and the Alpine. It was at first thought desirable to determine whether there might be a breed variation in regard to this characteristic, but due to the fact that such a small number of goats of the entire population kidded during the latter half of the year, it did not appear possible that such breed variation could exist.

As the duration of pregnancy is 150 to 151 days (Asdell, 2) the date of ovulation and conception can be computed with reasonable accuracy. Thus kids born in January result from estrus cycles occurring in August. From the above data it would appear that following the summer anestrum, the ovaries of a few does begin to function in August. Larger numbers come into estrum in September for the first time and by October estrus cycles are definitely established. These data are believed to indicate that

TABLE 1

Seasons variation in the frequency of births of milk goats

MONTH	NUMBER OF BIRTHS	PERCENTAGE OF TOTAL POPULATION	MONTH OF CONCEPTION (CALCULATED)
Jan. 1–15	625	1.68	August
Jan. 16–31	1260	3.40	
Feb. 1–15	2740	7.39	September
Feb. 16–29	4574	12.27	
March 1–15	6231	16.81	October
March 16–31	5077	13.62	
April 1–15	4326	11.67	November
April 16–30	3129	8.44	
May 1–15	2830	7.63	December
May 16–31	2165	5.84	
June 1–15	1168	3.15	January
June 16–30	761	2.05	
July 1–15	675	1.82	February
July 16–31	449	1.21	
Aug. 1–15	263	0.71	March
Aug. 16–30	169	0.46	
Sept. 1–15	77	0.21	April
Sept. 16–30	67	0.18	
Oct. 1–15	37	0.10	May
Oct. 16–30	31	0.08	
Nov. 1–15	37	0.10	June
Nov. 16–30	63	0.17	
Dec. 1–15	113	0.31	July
Dec. 16–31	207	0.56	
	37,047		

estrus cycles continue in non-pregnant does until late in February or March. Only under exceptional conditions will goats breed from April until July. Ovaries examined at this time show no large follicles or recent corpora.

Recent observations in other forms indicate that the anestrus condition is due to the lack of secretion of two hormones of the anterior pituitary which normally govern the function of the ovary. The injection of these hormones in the proper amounts should cause the ovaries to develop follicles and ripe eggs and thus permit conception to occur during the anestrus period. This would be a great stimulus to the goat milk industry as it would make it possible to have does kid in the fall and thus provide a more uniform supply of milk.

SUMMARY AND CONCLUSIONS

The date of birth of 37,047 kids of the four breeds of milk goats was tabulated to determine the frequency of births at various seasons of the

year. It was observed that about five per cent of the total population kid in January and that the number increases rapidly until the first half of March when over 16 per cent kid (30 per cent for month of March). From that time the number of births declines each month until July, when about 3 per cent kidded. From January to June over 93 per cent of all kids were born.

These data are interpreted as indicating that the milk goats of the United States are seasonal breeders. Considering the period of pregnancy as about 150 to 151 days or roughly five months, the anestrus period of the goat covers at least the months of April, May, June and July. In favorable seasons (cool?) some does will come into estrum in August. From September to February or March regular estrus cycles of about 21 days will occur in normal does with a seasonal anestrus period following.

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A COMPARISON OF THE CHEMICAL COMPOSITION OF PASTURE GRASS WITH A MIXED CONCENTRATE*

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INTRODUCTION

It has been the purpose of this investigation to ascertain whether or not on a dry matter basis a mixed pasture grass in the vegetative state, fertilized or unfertilized, is comparable from the standpoint of chemical composition with a mixed nitrogenous concentrate such as is fed to dairy cattle in New England.

The investigation has been confined to chemical studies but has gone beyond the scope of the ordinary fodder analysis by resolving some of the major proximate constituents into distinct groups, in order to give more reliable criteria from which to judge the nutritive value of the feeds as revealed by chemical analysis.

Interest has centered principally on the nature of the crude fiber, and the crude protein. The chief aim has been to determine the extent to which lignification has taken place, and in what forms the crude protein exists.

It is generally agreed upon among investigators that the protein content of pasture grass (1, 2, 3, 4) can be increased, and the crude fiber (2, 3, 4) and total dry matter (4, 5) decreased by a system of frequent clippings. The effect of fertilizers in general is to increase the protein (6, 7), and to decrease the crude fiber (6, 8, 9).

If it can be shown that grasses may be substituted for concentrates in the rations of dairy cows it might result, through the development of better and more permanent pastures, in cheaper feed for the New England dairyman.

EXPERIMENTAL PROCEDURE

The materials analyzed included two composite samples of mixed pasture grass, one from pasture which had received heavy annual spring applications of complete fertilizer, and summer appications of nitrogenous fertilizer. The other was from an area adjacent to the fertilized pasture, which had not received any fertilizer treatment. The complete fertilizer was equivalent to 85 pounds of nitrogen (N), 55 pounds of phosphoric acid (P_2O_5), and 67 pounds of potash (K_2O) per acre, while the nitrogenous fertilizer consisted of three separate applications of calurea, each equivalent to 10 pounds of nitrogen (N). The pasture was 50 acres in extent and

* Received for publication April 17, 1936; Contribution No. 247 from the Department of Chemistry, Massachusetts Agricultural Experiment Station.

was part of the area included in the regular grazing system on the State College farm. The land was quite level and the soil ranged from a medium loam to a silt loam. The herbage consisted principally of timothy, red top, Kentucky blue grass, and white Dutch clover. Small amounts of orchard grass, sweet vernal grass, Italian rye grass, meadow fescue, and rough-stalked meadow grass were also present.

Representative samples of the herbage were taken throughout the season, which extended from May to October in each of three years (1928–1929–1930). The pasture was kept in a uniformly grazed condition by a system of rotational grazing which is a modification of the so-called Hohenheim system. The samples represented herbage which averaged from four to six inches in height and were collected just before the cattle were turned into the plot. The sampling procedure was as follows: Six points were taken in each plot, three on each of its long dimensions, equidistant from each other, and one-third of the width of the plot from its edge. The points on each plot were not taken opposite each other but were "staggered." At each point a hollow wooden square with an inside area of 4 square feet was dropped on the grass and all herbage inside the square was cut with grass shears as closely as it was considered that cattle would graze, care being taken not to include any soil or grass roots. The grass as soon as cut was taken to the laboratory, air dried in a thin layer, ground, and carefully sub-sampled for analyses. For comparison a commercial mixed feed such as is commonly fed to dairy cows in New England was analyzed. This concentrate was designed for cows in milk receiving high quality barn-fed roughage and contained hominy, wheat bran, ground oats, cottonseed meal, corn gluten feed, old process linseed oil meal, distillers' grains, molasses, dicalcium phosphate, and salt.

PRESENTATION AND DISCUSSION OF RESULTS

A brief inspection of Table 1 will show the following outstanding facts:

TABLE 1

Fodder analysis

	UNFERTILIZED GRASS	FERTILIZED GRASS	MIXED CONCENTRATE
	%	%	%
Moisture (as analyzed)	6.49	6.16	9.74
Dry matter			
Crude protein	13.31	18.44	19.44
Crude fiber	24.41	22.99	7.72
Ether extract	2.78	3.03	5.44
N-free extract	51.46	45.94	60.22
Crude ash	8.04	9.60	7.18

(1) The application of fertilizer resulted in producing a grass of considerably higher protein, and decreased fiber content.

(2) The concentrate is characterized by a high protein, and a relatively low fiber content, and has a relatively high concentration of the storage groups. The subsequent tables show the results obtained by the analysis of some of the proximate fractions in Table 1.

(*a*) *Total Nitrogen*

TABLE 2

Nitrogen partition

	UNFERTILIZED GRASS		FERTILIZED GRASS		MIXED CONCENTRATE	
	Percentage in dry matter	Percentage in total nitrogen	Percentage in dry matter	Percentage in total nitrogen	Percentage in dry matter	Percentage in total nitrogen
Total nitrogen	2.13	.....	2.95	.....	3.11	.....
Protein nitrogen	1.94	91.08	2.72	92.20	2.93	94.22
Amino nitrogen	0.17	7.98	0.20	6.78	0.15	4.82
Ammoniacal nitrogen	0.02	0.94	0.03	1.02	0.03	0.96
Nitrate nitrogen	0.00	0.00	0.00	0.00	0.00	0.00

The facts presented in this table clearly show that:

(1) Fertilizer treatment increased the total nitrogen to almost the level of that found in the concentrate.

(2) The percentage of amino nitrogen in the total nitrogen is somewhat higher in the unfertilized than in the fertilized grass, and is considerably higher in the grasses than in the concentrate.

(3) The protein nitrogen together with the amino nitrogen constitutes about 99 per cent of the total nitrogen in all cases.

(4) Except for the amino acid fraction the partition ratios show very little difference between the grasses and grain, and practically none between the grasses.

(5) Nitrates were not detected in any case.

(*b*) *Cellulose and Lignin*

The grasses have considerably more cellulose than the concentrate, although this fraction is not paralleled by a correspondingly high percentage of lignin. Instead, we find the lignin of the grasses to be approximately 30 per cent as great as the cellulose, whereas the lignin in the concentrate is approximately 42 per cent as great as the cellulose present. In

TABLE 3
Cellulose and lignin

	UNFERTILIZED GRASS	FERTILIZED GRASS	MIXED CONCENTRATE
	%	%	%
Cellulose	18.30	16.28	8.17
Lignin	5.18	5.17	3.42

NOTE:—In Table 3 cellulose and lignin are considered instead of crude filter, since they form the largest part of this proximate constituent.

absolute percentage the lignin in the grass exceeds that in the concentrate by approximately 1.75 per cent.

(*c*) *Nitrogen-Free Extract*

TABLE 4
Nitrogen-free extract

	UNFERTILIZED GRASS	FERTILIZED GRASS	MIXED CONCENTRATE
	%	%	%
Reducing sugar	2.14	2.46	1.47
Sucrose	4.87	7.53	10.19
Starch	5.07	4.87	34.54
Pentosans	16.02	15.91	12.86
Hemicelluloses	20.06	17.68	6.51

The chief effect of fertilizer treatment in this fraction lies in an increased percentage of sucrose, and a decrease in percentage of hemicelluloses.

The most significant class difference is the high percentage of starch, and the low percentage of hemicelluloses in the mixed concentrate.

(*d*) *Ash*

TABLE 5
Ash

	UNFERTILIZED GRASS	FERTILIZED GRASS	MIXED CONCENTRATE
	%	%	%
Total ash	8.03	9.59	7.11
Insoluble ash	2.85	3.17	0.51
Soluble ash	5.18	6.42	6.60
Calcium	0.52	0.52	0.49
Magnesium	0.31	0.30	0.37
Phosphorus	0.29	0.31	0.98
Sulphur	0.58	0.56	0.53
Iron	0.07	0.12	0.06

Both soluble and insoluble ash were increased in the fertilized grass. The concentrate, while yielding the lowest total ash, furnished the greatest amount of soluble ash. The phosphorus was much higher in the concentrate.

A graphic presentation of the more significant foregoing results is portrayed in figures 1 and 2.

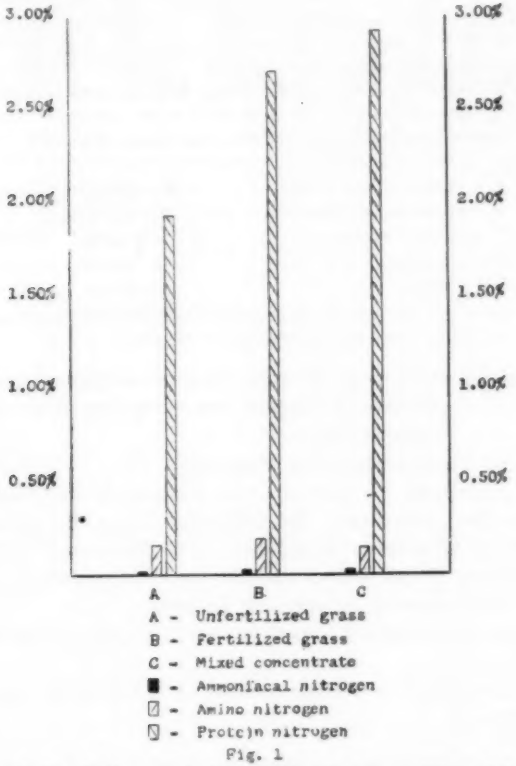

FIGURE 1. A distribution graph showing the nitrogen partition of the total nitrogen fraction of the feeds.

SUMMARY AND CONCLUSIONS

The following are the outstanding facts shown by this investigation:

(1) Pasture grasses contain a highly elaborated type of nitrogen irrespective of fertilizer treatment.

(2) The application of fertilizer had the following effects:

(a) An increase in the percentage of crude protein.

(b) A decrease in the percentage of crude fiber.

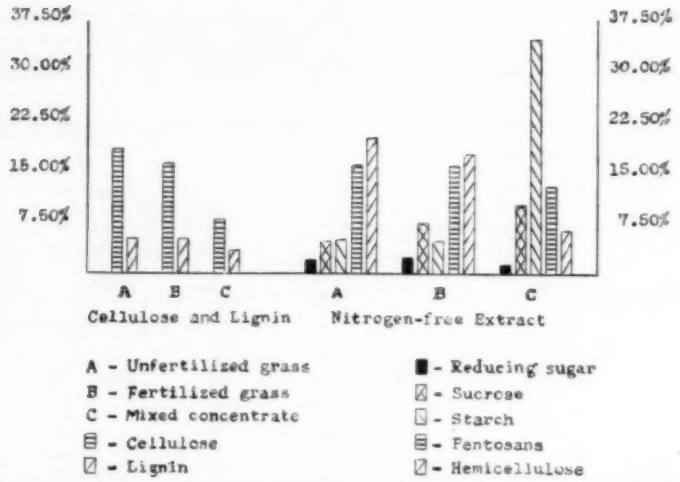

FIGURE 2. A graph showing the association of cellulose and lignin, and the various components of the nitrogen-free extract fractions of the feeds.

(c) A decrease in the percentage of nitrogen-free extract. An increase in sucrose was compensated by a decrease in hemicelluloses.

(d) An increase in the total ash.

(3) The percentage of crude fiber in the grasses was practically three times that in the concentrate, the difference being due principally to a larger amount of cellulose in the grasses. The lignin content of the grasses was approximately 30 per cent as great as the cellulose, while in the concentrate it was approximately 42 per cent as great.

(4) The grasses contained approximately 1.75 per cent more lignin than the concentrate.

(5) The concentrate was characterized by a relatively high percentage of sugar and starch.

These results supplementing other information in the literature would seem to justify the conclusion that for the dairy cow the dry matter of pasture grass in the vegetative state is comparable with concentrated feeds, and that its chemical composition can be so changed by the application of fertilizer that its character closely approaches that of a nitrogenous concentrate.

ACKNOWLEDGMENTS

The writer wishes to express his indebtedness to Professor J. G. Archibald, under whose direction this investigation was carried on, for his valuable criticisms and helpful suggestions; and to Dr. J. B. Lindsey, whose cooperation made possible this investigation.

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VOLUME XIX SEPTEMBER, 1936 NUMBER 9

JOURNAL OF DAIRY SCIENCE

Published by the

AMERICAN DAIRY SCIENCE ASSOCIATION
R. B. STOLTZ, Ohio State University, Columbus, Ohio, Sec-Treas.

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THE SCIENCE PRESS PRINTING COMPANY LANCASTER, PA.

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SPECIAL PUBLICATIONS

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National Institute for Research in Dairying, Reading, England

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Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE ON MILK AND MILK PRODUCTS

BUTTER

The Carotenoids of Butter. Albert E. Gillam and Isador M. Heilbron, Chem. Dept., Manchester Univ. Biochem. J. *29*, p. 839, 1935.

A chromatographic process (Tswett) was employed to determine the nature of the carotene in butter obtained from fat of normal and colostral milks. The data show that butter contains both α and β carotene, and that relative amounts of the isomerides vary considerably in different samples, the ratios of α to β forms ranging from 1 : 2.2 to 9 : 1 in normal butter, and 1.18 to 7.1 in colostrum butter (one sample mainly β form).

In addition to α and β carotene, more highly pigmented butters were found to contain minor amounts of other petrol phasic lipoid pigments, characterized as kryptoxanthin and lycopene. K.G.W.

Proper Salting—Its Importance in the Manufacture of High Quality Butter. C. D. Looker, Dir. of Res., Intern. Salt Co. Nat. Butter and Cheese J. *26*, 15, p. 18, August 10, 1935.

Clear flake or cube salt, 40 to 60 mesh, when it is practically free from chemical impurities and has been held in dry cool storage, aids in the production of high quality butter. Uniform distribution of salt and thorough working of the butter are essential. W.V.P.

Butter and Cheese Industry Developing in Argentina. Jule B. Smith, Assistant Trade Commissioner, Buenos Aires. Nat. Butter and Cheese J. *26*, 15, p. 10, August 10, 1935.

Data are given to show approximately the amounts of milk produced, methods of utilization and exports and imports of manufactured dairy products. In April, 1934, the ministry of agriculture formed "La Junta Reguladora de la Industria Lechera" to improve the economic status of the industry and the quality of the dairy products. Dairy firms are required to cooperate with the junta. About 10 per cent of the dairy equipment comes from the United States despite unfavorable exchange control and keen competition from European manufacturers. W.V.P.

Experiments Concerning Fishy Flavor in Butter (A Review of the Subject). W. Ritter. Schweizerische Milchzeitung No. 1, p. 101, 1934.

Lecithin splitting into trimethylamine is responsible for fishy flavor. Iron and copper are associated with the action. Oxidation without these

metals also causes this flavor. Bacteria are also frequently associated with this condition. W.R.

Fishy Flavor in Butter (The Metal Content of Butter and Cream). W. RITTER AND M. CHRISTEN. Schweizerische Milchzeitung No. 5, 1935.

The authors found that increased amounts of iron and copper in butter and cream frequently favored fish flavor development. Notable exceptions indicated that other points were involved. Bacterial action appeared to be significant. W.R.

Fishy Flavor in Butter (Influence of Adding Salts of Iron and Copper to Milk and Cream). W. RITTER AND M. CHRISTEN. Schweizerische Milchzeitung No. 7, 1935.

Tallowiness in milk was associated with 0.01 milligram of copper per liter. This defect was increased with high temperature pasteurization and holding cold 24–48 hours. A similar effect was produced with 0.5 milligram per liter. Adding hydrogen peroxide or hydrogen ions, or N-Methyl-p-amidophenol-sulfate stopped or retarded the development of tallowiness. Ascorbic acid did the same. Malic acid had a like action. Increasing heating temperatures decreased the tendency for this flavor to develop. W.R.

Experiments Dealing Wish Fishy Flavor in Butter (The Rôle of "Reduktobacterium frigidum"). W. RITTER AND M. CHRISTEN. Schweizerische Milchzeitung No. 12, 1935.

The authors found that certain alkali producing bacteria retarded fishiness in butter. Active cultures were required to do this work. W.R.

MILK

Production of High Quality Whipping Cream and Coffee Cream. R. T. KENNY, University of Illinois, Urbana, Ill. Milk Dealer *25*, 8, p. 78, May, 1936.

The author discusses the methods of increasing the viscosity of cream, causes and prevention of cream plug, causes and prevention of milk layer in bottled cream, normal acidity, and neutralization of cream, bacterial count of cream as compared with the count of milk from which it is separated, feathering of cream, factors affecting the whipping of cream, and the method of dispensing whipped cream known as instant whip. C.J.B.

Health Education Program. GEORGE H. WATSON. Milk Dealer *25*, 8, p. 38, May, 1936.

The author describes a Health Education Program which secured results for Foremost Dairies, Birmingham, Alabama. C.J.B.

Factors Responsible for Off Flavors in Milk. P. H. TRACY, University of Illinois, Urbana, Illinois. Milk Dealer *25*, 8, p. 114, May, 1936.

A discussion of some of the causes and methods of preventing off flavors in milk, especially rancid, oxidized, and tallowy flavors. C.J.B.

Delivery Cost Wastes that Eat into Profits. A. E. FRIEDGEN. Ice Cream Field *28*, 6, p. 10, April, 1936.

The author points out that many wastes in the operation of delivery trucks could be eliminated if the proper records were kept and used as a basis of economical operation. W.C.C.

Effects of Seasonal Milk Production on Marketing Costs. WAYNE CASKEY, Dept. of Agr. Econ., Univ. of Ill., Urbana, Ill. Milk Dealer *25*, 6, p. 68, March, 1936.

A study has been made of the effects of seasonal milk production on marketing costs in the New York, Philadelphia, and St. Louis milk sheds. The following conclusions are made:

1. The use of a weighted average price for paying the producers under the classified or use plan in the New York milk shed since May, 1921, resulted in widening the seasonal production of milk in this area.

2. The use of a basic-surplus plan for paying producers in the Philadelphia milk shed from 1919 to 1926 resulted in substantially narrowing the seasonal production in this area.

3. The New York milk shed could be reduced from a radius of 580 miles to 400 miles and still supply the market demand for whole milk, cream, and condensed milk, if seasonal milk production in New York were adjusted to the Philadelphia seasonal production.

4. The annual seasonal surplus in the New York milk shed could be reduced from 26 per cent to 10 per cent if its seasonal production were adjusted to the Philadelphia seasonal production.

5. A high seasonal surplus lowers the average price to producers since the market values of the manufactured products which absorb this surplus usually are not sufficiently high to pay premiums for high quality milk.

6. A wide seasonal production of milk results in the use of more trucks hauling the product than are necessary when the same volume is produced uniformly throughout the year. In a study of trucking operations in the St. Louis country plant areas, it was found that about one out of each four trucks now in use could be eliminated if the seasonal production in those areas were reduced to that in the Philadelphia milk shed.

7. A wide seasonal production of milk results in higher unit costs of country plant operations than a narrow seasonal production, since with a given capacity, total operating costs are about the same throughout the year. C.J.B.

Bottle Losses—How to Reduce Them. C. A. MOHR, Madison Consumers' Co-Operative, Madison, Wis. Milk Dealer *25*, 7, p. 84, April, 1936.

The author discusses breakage due to faulty glass or to careless handling prior to delivery to the milk plant and breakage after delivery to the plant. Various tests to which bottles should be submitted before acceptance are detailed and suggestions for preventing breakage and loss at the dairy are given. C.J.B.

Eliminating Butterfat Losses and Waste in Milk Plant Operation. J. R. BUTLER, Midwest Dairies, Inc., El Paso, Tex. Milk Dealer *25*, 7, p. 44, April, 1936.

The author describes how Midwest Dairies, by daily testing and constant vigilance, reduced butterfat losses from around 5 per cent down to 1 per cent or less. C.J.B.

Allocating Milk Plant Costs by the Factor System. JOHN R. PERRY. Milk Dealer *25*, 7, p. 40, April, 1936.

The author describes the factor system of milk plant accounting. In this system the plant costs of the various items handled are obtained so that the cost of each item as it leaves the plant can be found by adding the plant cost to the cost of the item laid down at the plant. The advantages of the factor system are simplicity, inexpensiveness, quickness, and accuracy. C.J.B.

Mechanical Can Washing a Necessity. J. M. TRITTENBACH, Sales Manager, Lathrop Paulson Co. Nat. Butter and Cheese J. *26*, 15, p. 22, August 10, 1935.

Efficient mechanical can washing delivers clean, odorless cans which are practically sterile at a cost of approximately 7 mills per can. W.V.P.

A Study of Milk Consumption in an Outer London Suburb. E. H. R. Southard. Lancet. *230*, p. 235, Jan. 25, 1936.

A survey of milk consumption in Southall, an industrial district of 47,000 population on the fringe of London, showed that just under half a pint per person is used daily. By means of the phosphatase test and bacterial counts, it was determined that 86 per cent of all milk used could be classed as "safe," and that 82 per cent was efficiently pasteurized. The author advocates compulsory pasteurization of all milk which is not otherwise bacteriologically controlled. J.A.T.

Plumbing Hazard Survey of Pasteurization Plants. W. SCOTT JOHNSON, Sanitary Engineer, Division of Health, St. Louis, Mo. Am. J. of Pub. Health *26*, 3, p. 229, March, 1936.

The author discusses the potential dangers of the contamination of milk from faulty plumbing in pasteurization plants. A survey of six plants revealed 210 plumbing defects involving 28 different kinds of milk plant equipment.

Defects are classified according to six general types and according to equipment involved. Faulty conditions are due to defective plumbing installations and fixtures, poor design of milk plant equipment, and inexperienced planning of the location and capacities of sewage systems within milk plant buildings. These hazards to health should be eliminated. The responsibility for the administration of the program for correcting existing defects and prevention of future ones should rest with the health department. M.W.Y.

Vote Permissive Pasteurization of Certified Milk at Conference. TORREY STEARNS. Cert. Milk *10*, 111, p. 3, July, 1935.

Permissive pasteurization was voted into the official "Methods and Standards for the Production of Certified Milk" at the joint conference of the Certified Milk Producers' Association of America and the American Association of Medical Milk Commissions held June 10 and 11 at Atlantic City, N. J. The action permits producers of certified milk throughout the United States to market pasteurized certified milk in addition to the widely-known raw certified milk, provided this meets the approval of the local Medical Milk Commission. W.S.M.

Metal-free Dairy Products an Essential Adjunct of Metal-free Treatment. L. E. GAUL AND A. H. STAND, New York. Cert. Milk *10*, 107, p. 3, March, 1935.

The authors point out the possible relationship between various disease processes and the absorption of relatively minute quantities of the metallic elements present in water, beverages, dairy products and foodstuffs, including dairy products. The metallic content of dairy products was determined by a spectrographic analysis, the technique of which is outlined. Special advantages of the spectrographic method of analyzing dairy products are given. W.S.M.

Some Physico-Chemical Properties of Lactose. H. H. SOMMER, Dairy Dept., Univ. of Wis., Madison, Wisconsin. Ice Cream Rev. *18*, 8, p. 46, March, 1935.

Lactose exists in milk or any solution in two modifications—alpha-lactose and beta-lactose. Alpha-lactose is the least soluble of the two modifications and under ordinary conditions will be the first to crystallize. The two forms exist in solution in equilibrium at a definite ratio of one to the other. When

some of the alpha-lactose crystallizes out, this equilibrium is disturbed and some of the beta-lactose will undergo transformation into the alpha modification.

Both forms of lactose are optically active and the optical rotation can be measured in angular degrees by the polariscope. The two forms are dissimilar in their optical rotatory power. When alpha lactose is dissolved and the optical rotatory power determined the very first reading will be due to the alpha-lactose. As time passes some alpha will change to beta-lactose and there is a corresponding change in the polariscope reading. This drift or change in the reading will continue until the two modifications are in equilibrium. The phenomenon is known as mutarotation. J.H.E.

Magnesium Studies in Calves. I. Tetany Produced by a Ration of Milk or Milk with Various Supplements. C. W. DUNCAN, C. F. HUFFMAN, AND C. S. ROBINSON, Mich. Agr. Exp. Sta., East, Lansing, Michigan. J. Biol. Chem. *108*, 35, 1935.

Previously reported experiments have shown that attempts to raise calves to maturity on a ration of whole milk alone have consistently failed, except when the whole milk ration was supplemented with alfalfa hay. On a whole milk ration, a train of symptoms of functional disturbance, such as irritability, excitability, anorexia, neuric muscular activity and tetany, followed by death, may occur. These symptoms closely parallel those following extirpation of or injury to the parathyroid glands; the frequent occurrence of hypocalcemia has often been considered an explanation for the condition. The symptoms, however, have been observed when the blood calcium was normal.

Experiments with 25 calves given a whole milk ration with or without various supplements, such as cod-liver oil, linseed oil, minerals, yeast, and parathormone were conducted. Tetany was observed to occur in twenty calves which had normal blood calcium and inorganic phosphorus; with five other calves tetany was observed when blood calcium and phosphorus were normal, and was associated with a low blood magnesium. The Ca : Mg ratio in calf blood is normally 4 : 1 to 5 : 1, whereas a sustained whole milk ration increases this ratio 8 : 1 to 10 : 1, owing solely to a decrease in blood magnesium. Normal blood magnesium values range from 2.25 to 2.75 mg. per 100 cc. of plasma, and in calves suffering from low magnesium tetany, 1.2 to 1.6 mg. Low magnesium tetany does not occur on the average calf's ration because they are able to utilize magnesium more efficiently when they have access to roughage. While calcium and phosphorus requirements are maintained by increasing the milk intake, the same is not true for magnesium.

K.G.W.

The Effect of Ingested Cod-Liver Oil, Shark Liver Oil, and Salmon Oil Upon the Composition of the Blood and Milk of Lactating Cows. C. M. McCoy, and L. A. Maynard, Cornell Univ., Ithaca, New York. J. Biol. Chem. *109*, 29, 1936.

The feeding of cod-liver oil to a lactating cow is known to cause a significant reduction of the fat percentage in the milk. The changes that take place within the body that may lead to this repression of fat secretion have been unknown. Five cows were fed 168 cc. of cod-liver oil, shark liver oil, and salmon oil for periods of two weeks with periods without oil between. The usual fat repressant action of cod-liver oil was observed, whereas the significance of the effects of the other oils was wanting. Feeding of pasture grass did not counteract the effect of cod-liver oil. The non-saponifiable fraction of cod-liver oil had no effect upon milk fat, while the tri-glycerides seem to carry the injurious repressant fraction. The ingestion of the oils did not affect normal milk yield and in every case a rise occurred in the iodine number of the milk fat. Blood samples were taken simultaneously from the mammary and jugular veins of three of the cows at weekly intervals. The analyses indicate that the mammary gland takes true glucose from the blood rather than other reducing substances; similarly, the total plasma lipids of mammary blood was significantly less than in jugular blood. No similar reduction was observed in the amounts of blood plasma lipoid phosphorus and inorganic phosphorus. The data indicate that cod-liver oil exerts its effect directly on the mammary gland, rather than by alteration of blood composition. K.G.W.

Prophylaxis of Rickets in Premature Infants with Vitamin D Milk. L. T. Davidson, K. K. Merritt and S. S. Chipman, Dept. of Diseases of Children, Columbia Univ., the Babies Hospital and the Sloane Hospital for Women, N. Y. Am. J. Dis. Child. *51*, p. 1, Jan., 1936.

Eleven premature infants were given vitamin D milk, from cows fed irradiated yeast, during the first six months of life to determine how far they could be protected from rickets by this means alone. Roentgenograms of the forearms and wrists were made bimonthly from birth to four months of age and then monthly through the sixth month. Serum calcium and phosphorus were determined monthly. By roentgenogram, two of the infants remained free from rickets throughout the study; the other nine showed rickets of mild degree from the third to the fifth month, which had satisfactorily healed by the sixth month without change in the antirachitic regimen. In only one instance was the calcium-phosphorus product found to be definitely lowered. W.H.R.

Influence of the Ration on the Vitamin C Content of Milk. W. H. Riddell, C. H. Whitnah, J. S. Hughes and H. F. Lienhardt, Kans. Exp. Sta., Manhattan, Kan. J. Nutrition *11*, p. 47, Jan., 1936.

Using two cows to a lot the vitamin C content of the milk produced from the following rations was determined by both biological assay and chemical test: 1. Sorghum silage and a grain mixture with access to good brome and bluegrass pasture; 2. A winter ration of alfalfa hay, sorghum silage and a grain mixture; 3. A winter ration of alfalfa hay and grain. The results indicated that the rations studied had no significant influence on the vitamin C content of the milk. L.A.M.

Examinations on Heat Resistant Strains of *B. coli*. W. HENNEBERG AND H. WENDT, Prussian Dairy Research Institute, Kiel, Germany. Zentr. F. Bact. *2*, 93, p. 39, October, 1935.

Strains of *B. coli*, that survive 63° C. for 24 to 30 minutes are very rare in milk. The same is true with pasteurizing apparatus. It may be that they live there in coccoid forms so that they may not easily be distinguished from the almost abundantly occurring micrococci. It was not possible to distinguish the resistant and non-resistant strains by any other differential method. The ability to resist heat was found to be very variable with the same strain, an experience which had been also made independently at the research institute in Weihenstephan (By Demeter). It is furthermore demonstrated that a persistent good nutrition (extract of bruised rye) may transform non-resistant strains into resistant ones. A special "physiological condition" may play an important part. In a few cases the heating of the bacteria was followed by certain physiological and morphological changes, namely, the colonies lost the red color on Endo-fuchsin-agar, the cells became round, and the ability of acid production vanished. Those coccoid forms are to be considered as degeneration forms. K.J.D.

On the Symbiotic Functions of Oidium Lactis. J. B. LINNEBOE AND E. G. HASTINGS, Univ. of Wis., Madison, Wis. Zentr. f. Bact. *2*, 93, p. 278, Jan., 1936.

The bacteria, whose symbiosis with *Oidium lactis* was studied, were *Strept. lactis, Bact. coli* and *Bact. mesentericus*. There was no change in acidifying and clotting of milk by the acid bacteria, whether growing with or without *Oidium lactis*. The aroma which developed was rather unpleasant in the milk cultures of *Bact. mesentericus* together with *Oidium lactis*. The symbiosis promoted in an extraordinary way the longevity of the acid formers. The pH of the mixed cultures was increased in every case, when the Oidium had started its proteolytic and acid consuming activity. There was an intimate connection between the Eh-values and the logarithmic growth curves, but the influence of the symbiosis on the final values was very different. K.J.D.

***Bacterium Bifidum* and *Thermobacterium Intestinale*.** S. ORLA-JENSEN AND O. WINTHER, Royal Polytechnic Institute, Copenhagen, Denmark. Zentr. f. Bact. *2*, 93, p. 321, Feb., 1936.

Bact. bifidum is not, as Rettger and Weiss contended (1934), a variety of the intestinal bacillus, called Acidophilus. Furthermore *Thermobacterium intestinale* is not to be confused with *Bac. acidophilus* Moro. *Th. intestinale* may rather be confused with *Thermobacterium lactis*, but this organism almost always forms sharply edged colonies, produces pure l-lactic acid and is not stimulated by fecal extract. It is also easily differentiated from *Thermobacterium cereale*, because this organism does not live whether in milk nor in fecal material and is almost unable to ferment lactose.

K.J.D.

Sugar and Lactate Fermenting Butyric Acid Bacteria. J. VAN BEYNUM AND J. W. PETTE, Agr. Exp. Station, Hoorn, Holland. Zentr. f. Bact. *2*, 93, p. 198, Dec., 1935.

Only those butyric acid bacteria are dangerous for cheesemaking, which do not liquefy gelatin and are able to ferment lactate. Most of the examined strains have been isolated from milk by means of the Weinzirl test, acidifying the original milk by 2–3 cc normal sterilized lactic acid to 100 cc. The culture medium was autolyzed yeast plus 1.5 per cent sodium lactate (pH 5, 8–6, 0). It could be readily shown that there are non-liquefying strains, which ferment lactose and which do not, and that those strains, which ferment lactate, cannot ferment lactose and *vice versa*. The first group may keep the name "*Clostridium saccharobutyricum*" (including *Cl. butyricum*). For the second group the authors proposed the name "*Clostridium tyrobutyricum*," because only this group is important for cheesemaking. This group is not very active in carbohydrate splitting: regularly ferments only glucose and lactate, almost always levulose, sometimes galactose and arabinose. There is more butyric acid formation out of glucose by this group than by the first group.

That the first and not the second group causes the gassy butyric acid fermentation in cheese, could be shown experimentally. There is unfortunately no direct test for proving the existence of *Cl. tyrobutyricum* in milk and cheese. The indirect way is the following: The bacteria are enriched in glucose medium and afterwards inoculated into yeast autolysate plus lactate and peptone solution plus mannite. In the first medium only *Cl. tyrobutyricum* will grow, in the second one only *Cl. saccharobutyricum*. The Weinzirl test in the above mentioned modification is only a test on butyric acid bacteria as such, without differentiating between the two groups.

K.J.D.

Existence and Activity of Yeasts in the Milk. H. GLATHE, Univ. of Leipzig, Germany. Zentr. f. Bact. *2*, 92, p. 61, April, 1935.

On a farm it was impossible to get butter even after 12 hours churning of the cream. A short time after beginning of churning the interior of the churn was filled with heavy foam. The bacteriological examination of the cream, which had an acidity of 0.135 per cent, revealed that the microflora consisted mainly of yeasts. True Saccharomycetes were determined to be the real cause of the fault. They were not further classified, however. The foaming was caused by the CO_2-production of these Saccharomycetes. Their origin could be traced to the water in the barn which had been enriched by fruit-feeding. K.J.D.

Experiments with Acid Formation. W. RITTER AND M. CHRISTEN. Landwirtschaftliche Jahrbuch der Schweiz. p. 749, 1935.

The authors found that with acid forming bacteria the production of lactic acid and acetone, and di-acetyl is not in a regular order. The same cultures may vary the amounts of each produced. Adding citric acid in small amounts stimulates acid and acetone development.

Hydrogen peroxide is produced in the presence of streptococci when air is injected into the culture or buttermilk but the activity in both is different. W.R.

A Sequel to a Public Health Ruling Concerning Streptococci Mastitis. C. S. BRYAN AND G. J. TURNEY, Mich. Agr. Exp. Sta., East Lansing, Mich. and Dept. of Health, Lansing, Mich. Am. J. of Pub. Health, *26*, 5, p. 517, May, 1936.

The finding of streptococci of mastitis in the milk from 18 out of 20 dairies selling raw milk in the City of Lansing, Michigan, led to a Board of Health ruling that all raw milk sold in the City of Lansing must be produced by cows free from streptococci mastitis. Animals producing such raw milk must be tested every 6 months thereafter and found free of infectious mastitis. Any reacting animals must be removed from the herd. The author discusses the results which were obtained in detecting and eliminating infected cows from the herds. M.W.Y.

Veterinary Service in the Control of Dairy Products. JOHN G. HARDENBERGH, V. M. D. Dir. of Lab, The Walker-Gordon Lab. Co., Inc., Plainsboro, N. J. Am. J. Pub. Health *26*, 6, p. 597, 1936.

Veterinary service in the control of dairy products embraces wide and varied fields of activity which are discussed in this article. Some of the topics are (1) control of bovine diseases and safe milk; (2) official milk and dairy inspection service, and (3) industrial milk and dairy inspection service. M.W.Y.

Attainable Standards in the Bacterial Counts of Raw and Pasteurized Milk. M. E. BARNES, State Univ. of Iowa, Iowa City, Iowa. Am. J. Pub. Health *26*, 6, p. 561, June, 1936.

The lack of adequate official supervision over the milk supply for the Children's Hospital and the surrounding community led to the organization of a University Department of Health. This paper summarizes the studies of milk production over 43 months during which a raw milk supply was greatly improved in quality as indicated by bacterial counts. On the basis of this performance, a bacterial count of 2,000 per cc was regarded as the upper limit of an ideal zone. Similar studies in pasteurized milk led to the use of maximum bacterial counts as the criterion of excellence, 1,000 per cc being regarded as the upper limit of the ideal zone. M.W.Y.

Differentiation of *Streptococcus pyogenes* from Man and Animals by the Sorbitol-Trechalose Test. F. C. MINETT. J. Path. Bact. *40*, p. 357, 1935.

Examination of a series of *Streptococcus pyogenes* from the human body and from cow's milk gave support to the view that streptococci of this kind from man are trechalose fermenters, whereas those which may be found in cow's milk are ordinarily sorbitol fermenters. Considered in conjunction with the work of previous observers, the sorbitol-trechalose test appears to be a simple test of considerable value in establishing the original source of streptococci of this kind when present in milk. F.W.F.

Bovine Phthisis. Its Incidence in North-East Scotland. A. S. GRIFFITH AND J. SMITH. Lancet. *229*, p. 1339, Dec. 14, 1935.

Bacteriological examinations of 103 cases of pulmonary tuberculosis revealed that in 13 instances tubercle bacilli of the bovine type could be found in the sputum. All strains were typical of the bovine strains in that they grew sparsely on media, and none showed the typical luxuriant growth of the human tubercle bacilli. In only 5 of these cases had there been a history of previous glandular tuberculosis. These 5 were considered to have been infected by milk from tuberculous cows. The source of infection in the other 8 cases was not determined. This series of cases of pulmonary tuberculosis has yielded the highest precentage of bovine infections yet recorded for this form of human tuberculosis, although this may have been due to chance grouping. J.A.T.

Undulant Fever. With Special Reference to its Clinical Aspects in England and Wales. W. DALRYMPLE-CHAMPNEYS. Lancet. *229*, p. 1449, Dec. 28, 1935.

Of 255 undulant-fever patients in the author's series, 170 were males and 85 were females. Of 250 patients of known age, 107 were in the age

group between 30 and 40 years. The author believes that consumption of cow's milk is the commonest mode of infection, although in many instances the etiology is obscure. Where milk is *efficiently* pasteurized, as in London, the disease is almost unknown.

In discussing the clinical course and diagnosis of undulant fever, the author stresses the necessity and efficiency of the agglutination test, especially when a large range of dilutions is employed. In outlining treatment, vaccines are stated to be uncertain in effect, and drugs should be used sparingly. Diet and rest are important. The mortality is low, only 9 deaths having occurred in 290 cases. J.A.T.

Fifty Years of Progress in the Dairy Business. H. P. Olsen, Milwaukee, Wisconsin. Nat. Butter and Cheese J. *26*, 15, p. 28, August 10, 1935.

A brief historical review of the introduction of centrifugal separation of cream. Pictures of early creamery machinery are reproduced. W.V.P.

XVIII. A New Spectroscopic Phenomenon in Fatty Acid Metabolism. The Conversion of "Pro-Absorptive" to "Absorptive" Acids in the Cow. William Dan, Thomas Moore, Roland G. Booth, John Golding, and Stanislaw K. Kon. Nutrition *Lab.*, Univ. of Cambridge, England and National Inst. for Research, Univ. of Reading, England. Biochem. J. *29*, 138, 1935.

In previous work the authors have shown that when the cow is turned out to pasture after the winter, the fatty acids obtained from the butterfat show greatly increased absorption for radiation of wave-length 230 mu. Experiments were conducted, using various oils (sardine, cod-liver, linseed and rape oil) to determine the nature of the phenomena. The absorption of radiation at wave-length 230 mu by acids obtained from the oils (termed "pro-absorptive" acids) is small. When fed to cows the acids caused the butterfat to possess a much greater absorption in this region. When the fatty acids from the oils were subjected to prolonged saponification, they acquired a much greater absorptive property for radiation at 230 mu wave length. Thus certain acids from the oils may be converted from "pro-absorptive" or slightly-absorbing acids to "absorptive" or strongly absorbing acids either in *vivo* or in *vitro*. When the converted "absorptive acids" were fed cows, the absorption property of the butter acids increased rapidly. When, however, "pro-absorptive" acids were fed, and the butterfat acids then subjected to saponification, no further increase in absorption properties of the latter were noted. It seems probable the ingested "pro-absorptive" acids are either completely transformed into a strongly absorption substance or are not secreted into the milk. The nature of the change from slight to strongly absorbing acids is not known; it appears probable that the property

is confined to acids having two or more unsaturated linkages, and that intra-molecular rather than oxidative changes take place. K.G.W.

State Regulation of Bottled, Homogenized Milk. Milk Dealer, *25*, 8, p. 36, May, 1936.

A survey, conducted by the Milk Dealer, in which they received word from 39 states and the District of Columbia, showed that of these states, Alabama, Arkansas, Iowa, Kansas, Maine, Massachusetts, Michigan, Missouri, New Hampshire, New York, South Carolina, Texas, Utah, Virginia, Wisconsin had no regulations on homogenized milk. California, Colorado, Connecticut, District of Columbia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Minnesota, Montana, Nebraska, Nevada, New Jersey, New Mexico, North Dakota, Pennsylvania, Tennessee, and Washington permit the sale of homogenized milk, provided it is properly labeled. Florida and South Dakota had not been forced to rule on its legality, but did not look upon it with favor; and Georgia, Mississippi, North Carolina and Wyoming do not permit the sale of homogenized milk.

ICE CREAM

Recent Tendency Toward more Stringent Sanitary Requirements. H. H. Sommer, Univ. of Wis., Madison, Wis., Ice Cream Field *28*, 6, p, 9, April, 1936.

The realization that organisms causing diphtheria, scarlet fever, typhoid, septic sore throat and gastro-intestinal disorders, survive the freezing and storage temperatures in ice cream has done much to make the sanitary regulations strict. Recently the advent of the counter freezer has been an impetus to even more rigid requirements.

These regulations may involve the following:

(1) Maximum bacterial counts,
(2) Ingredients from inspected sources,
(3) Pasteurization of flavors and colors,
(4) Pasteurization under specified conditions,
(5) Negative test for *E. coli* on the finished mix,
(6) Precautions against recontamination after pasteurization,
    (a) health of attendants
    (b) sterilization of equipment
    (c) freezing at the point where the mix is made and pasteurized.

It is suggested that nut cracking plants should be under supervision since contamination can occur as a result of human contact.

It is pointed out that equipment with which the ice cream comes in contact after pasteurization of the mix should effectively be sterilized and practical sterilization can be accomplished by the use of either steam, scalding hot water, or chemicals. W.C.C.

Flavor Defects in Ice Cream, their Causes, How to Remedy them. C. D. DAHLE, Penn. State College, State College, Pa. Ice Cream Field *28*, 6, p. 12, April 1936; *28*, 7, p. 18, May, 1936.

The main defects given on the ice cream score card are discussed from the point of view of cause and remedy. W.C.C.

Quick and Easy Ways of Turning out Fancy Brick Orders. J. O. CLAITOR. Ice Cream Field *28*, 7, p. 9, May, 1936.

The author describes three ways of utilizing specially made core cutters in preparing center mold bricks. The basis of the method consists essentially in preparing bricks of ice cream, then cutting out the core as desired by the use of the core cutters while the ice cream is hard, and finally filling the core with a different kind of ice cream. W.C.C.

Materials for the Insulation of Ice Cream Plants and their Costs. F. B. FULMER. Ice Cream Field *28*, 7, p. 10, Map, 1936.

The author discusses some of the general requirements of materials for the insulation of ice cream plants. W.C.C.

What Quality Improvement can do for us. A. D. BURKE, Dairy Dept., Alabama Polytechnic Institute. Ice Cream Field *28*, 4, p. 12, Feb., 1935.

The author points out that in the long run quality ice cream will win. In order to maintain high quality ice cream the following rules must be observed, he states:

(1) Process the mix according to fundamental principles of quality production, (2) Attain proper legislation to curtail the manufacture of cheap products at the same time providing reasonable and workable health regulations to protect the consuming public, (3) Maintain industry cooperation through trade associations, (4) Encouraging and profiting by ice cream judging contests and exhibits. W.C.

Proper Storage Temperature of Frozen Fruit. J. C. HENING, New York Agr. Exp. Sta., Geneva, N. Y. Ice Cream Field *26*, 3, p. 22, Jan., 1935.

The author concludes as a result of experiments in freezing and storing strawberries and raspberries for use in ice cream, that storage at 0° F. is preferable to storage at 15° F. to 18° F. as recommended by certain other workers; especially is this true if the fruit is to be held in storage from season to season. W.C.

The Construction and Maintenance of the Cold Room. C. D. DAHLE, Penn. State College, State College, Pa. Ice Cream Field *28*, 2, p. 12, Dec., 1935.

The author sketches the evolution of the methods used in hardening ice cream, mentioning the following as being important developments: brine boxes, ice cream cabinets, still-air hardening rooms, gravity system refrigerator rooms. When the capacity of a plant reaches 50 to 75 gallons of ice cream per day, a hardening room is recommended. It is suggested that 9 to 10 inches of cork insulations be used for hardening rooms and 4 inches for milk storage rooms.

Although direct expansion ammonia refrigeration is generally practiced, where extremely low temperatures (−40° F. to −50° F.) are required the carbon dioxide compressor may be used. It is a matter of conjecture, whether it pays one to use temperatures as low as −30° F. to −40° F. in order to harden package ice cream in 30 to 40 minutes, if one can harden the same packages in 2 to 3 hours at a temperature of −15° F. with the use of fans or blowers. It is pointed out that the use of fans to aid in rapid freezing is a less expensive method than attempting to do this with extremely low temperature without circulation of air, and instances are cited where by this method under commercial conditions the hardening time has been decreased one half or more.

It was found that pint samples hardened in 1¼ hours were only slightly smoother than those hardened in 2½ hours, whereas those hardened in 10 hours were criticized as being coarse. It is reported that increasing the drawing temperature 2.4° F. increases the hardening time 4.05 hours and decreased by one point the score on body and texture.

It was observed that small packages harden more quickly than do larger containers, but the difference in texture often favors bulk ice cream because of improper filling and handling of the packages. W.C.C.

Defects of High-solids Mixes and their Cure. M. J. Mack, Mass. State College, Amherst, Mass. Ice Cream Field *27*, 3, p. 24, July, 1935.

The author reports a series of investigations with ice cream mixes containing from 16 to 25 per cent butterfat, the majority of which contained from 18 to 20 per cent butterfat. With this type of mix the following defects may be expected: (1) excessive viscosity which interferes with efficient homogenization, cooling, freezing and packaging; (2) unsatisfactory melting appearance; (3) a crumbly body which makes serving of the ice cream difficult. The author discusses the means used to overcome these defects and summarizes the results as follows:

1. High-solids ice cream mixes, when made under usual processing conditions, are excessively viscous and produce crumbly ice cream possessing an undesirable melting appearance.

2. The use of butter, frozen cream or plastic cream in place of all or a part of the sweet cream needed to supply the butterfat markedly increases these defects.

3. The use of three successive stages of homogenization entirely eliminates the problem of excessive viscosity and decreases the other defects already named. Pressures of 2,000, 500 and 150 pounds are suggested as satisfactory maximum pressures for the first, second and third valves, respectively, when homogenizing an 18 per cent butter fat mix. With a 20 per cent fat content, somewhat lower pressures of 1,500, 500 and 150 pounds are suggested as maximum pressures.

4. A crumbly body may be prevented in high-butterfat ice creams by increasing the sugar content to 16–17 per cent, depending somewhat upon the fat content of the mix. If the use of cane sugar alone produces an excessively sweet taste, the substitution of corn sugar for 3–4 per cent of the cane sugar is recommended.

5. Increasing the sugar content to 16–17 per cent improves the melting appearance of high-fat ice creams and reduces the melting resistance of such ice creams.

6. Three-stage homogenization entirely eliminates the excessively high viscosity which invariably occurs in chocolate ice cream mixes of high solids content.

Editors' note: High-solids mixes refers to high-fat mixes in this article.

W.C.C.

New Developments in the Homogenization of Ice Cream Mix. H. H. Sommer, Dairy Dept., Univ. of Wis., Madison, Wis. Ice Cream Rev. *18*, 12, p. 48, July, 1935.

The efficiency of homogenization involves two considerations: (1) the size of the globules to which the fat has been subdivided, and (2) the clustering or non-clustering of the globules. The size of the globules that are present in the product after homogenization depends on a number of factors enumerated as follows:

1. The coarseness or fineness of the original emulsion.
2. The fat concentration in the product being homogenized.
3. The temperature of homogenization.
4. The valve clearance in the homogenizing valve.
5. The design of the valve.
6. The homogenizing pressure.

Large clusters of globules are almost as detrimental to whipping ability, body, and texture as large globules. The factors which affect clustering are:

1. The fat concentration.
2. Homogenizer valve conditions—design and whether one, two, or three three stages.
3. Homogenizing pressure and temperature.
4. The presence of sugar, gelatin and egg yolks.
5. The effect of salts and reaction.

The effect of a number of these factors on clustering can be explained on the basis of the charge on the globules, on the theory that a high charge tends to keep the globules apart by mutual electrostatic repulsion. J.H.E.

Technical Control of Ice Cream with Sodium Alginate. CLARK GOODMAN, Kelco Co., San Diego, California. Ice Cream Rev. *18*, 7, p. 42, Feb., 1935.

The author reports that a vegetable stabilizer manufactured from kelp and technically known as sodium alginate gives satisfactory stabilization of ice cream. Experimental and commercial data are presented comparing sodium alginate with gelatin in similar ice cream mixes. The amounts of stabilizers used were 0.3 per cent gelatin (250 Bloom strength) and 0.25 per cent sodium alginate.

The organoleptic tests for texture were supplemented with photomicrographs. Sodium alginate is said to possess superior texture improving qualities. Accelerated exposure tests made by transferring 2½ gallon samples of sodium alginate ice cream back and forth every 24 hours between two cabinets, one maintained at 16° to 18° F., the other at 4° to 6° F., for ten days also demonstrated the efficacy of sodium alginate as an ice cream stabilizer.

Data are presented comparing the whipping time of sodium alginate and gelatin mixes in a batch freezer. Mixes containing the sodium alginate were found to whip to 100 per cent overrun in slightly less time than similar mixes containing gelatin. Melting tests of the ice creams showed the sodium alginate ice cream to melt faster than the gelatin product. J.H.E.

Sandiness: Its Causes and Prevention. G. L. GIBSON. Ice Cream Field *27*, 1, p. 28, 2, p. 28, May and June, 1935.

The following points were given major consideration in the study: (1) The use of special concentrated skimmilk products to increase the serum solids content above normal; (2) Influence of pasteurization temperature upon the development of sandiness; (3) Relation of fat clumping to lactose crystallization. Organoleptic methods of comparison were used throughout the experiments as a basis of determining the occurrence of sandiness. The following conclusions are drawn:

1. Increasing the serum solids above that normally occurring in ice cream with either Hi-Solids, Pro-Lac, Kraftogen B.D. or regular skimmilk powder lowered the minimum temperature and increased the time required to whip the ice cream to 100 per cent overrun.

2. Adding Hi-Solids or skimmilk powder at the freezer resulted in an uneven distribution of the powder throughout the ice cream. There was a tendency for more of the products to be in the first portion of the ice cream drawn from the freezer than in later portions.

3. Increasing the serum solids above that normally occurring in ice cream decreased the heat resistance of the ice cream.

4. The special concentrated skimmilk products studied did not improve the flavor of ice cream. Pro-lac powder produced a "malt" flavor and it also made the ice cream taste salty. In all cases a milk powder flavor was noted in ice creams containing increased serum solids. Hi-Solids milk powder produced an ice cream a flavor comparable to that imparted by high-quality skimmilk powder.

5. The special concentrated milk products studied, except Pro-Lac, improved the body of the ice cream. A spongy and somewhat sticky body occurred when Pro-Lac powder was used to build up the serum solids in ice cream. Too much Hi-Solids (6 per cent or more) produced a dry, powdery body. Skimmilk powders prepared by the spray and vacuum roll processes gave results similar to those of Hi-Solids when added at the freezer. The atmospheric roll type of skimmilk, on the other hand, caused the ice cream to be dry and rough.

6. Under commercial conditions, where temperature fluctuations were slight and the turnover quite rapid, it was found that the special concentrated skimmilk products studied could be used to build up the serum solids in ice cream without much danger of sandiness developing. However, under severe storage conditions, the ice creams containing added solids became sandy sooner than ice creams with normal percentages of serum solids. Ice cream containing regular skimmilk powders became sandy sooner than those to which Hi-Solids had been added. Both Pro-Lac and Kraftogen B.D. proved slightly better than Hi-Solids in this respect.

7. Lactose crystallization in ice cream was not materially retarded by pasteurizing the milk between 160° F. and 175° F. when compared to 145° F.

8. Clumping of the fat globules in ice cream, induced by adjusting the homogenizing pressure and temperature, did not seem to delay lactose crystallization.

W.C.C.

A Survey of the Age and Condition of Package Ice Cream as Bought by the Consumer. A. C. SCHRICKER, St. Louis Dairy Co., St. Louis, Mo. Ice Cream Rev. *18*, 7, p. 34, Feb., 1935.

A survey of the flavor, body, age, and appearance of package ice cream as bought by the consumer representing six months of study by the Missouri Ice Cream Manufacturers' Association's Research Committee. Packages of different brands were purchased from different dealers, at ten-day intervals and scored by members of the research committee. The survey was limited to two types of combination packages, the neapolitan package and a special featured by the various manufacturers. It was found that in a combination

package of ice cream its quality is no better than its weakest flavor, which in the case of neapolitan was strawberry. The body of the ice cream in most of the packages was found to be good.

The age of most of the packages could be identified because of code. The age of each group investigated was classified. Of the neapolitan packages picked up, 5.7 per cent were known to be only a week old, 31.4 per cent two weeks old, 17.1 per cent three weeks old, 11.5 per cent four weeks old, 11.5 per cent five weeks old, and 22.8 per cent of which the age could not be determined. In the special feature package, 22 per cent were a week old, 48.2 per cent were two weeks old, 14.2 per cent three weeks old, and 4 per cent age unknown.

The appearance of 77.2 per cent of the neapolitan packages picked up was scored as good, 22.8 per cent being soiled. In the special packages 85.2 per cent scored good, and 14.8 per cent were soiled. Eighty-eight per cent of the packages picked up were firm, and 12 per cent were quite soft.

The findings of the committee bring out the importance of age in governing the quality of ice cream reaching the consumer. J.H.E.

Dry Egg Yolk for Ice Cream. J. H. Erb, Dept. of Dairy Tech., Ohio State Univ., Columbus, Ohio. Ice Cream Rev. *18*, 8, p. 41, March, 1935.

Seven brands of dried egg yolk as used in ice cream were subjected to a number of laboratory tests to indicate their purity, freshness and solubility. The various samples were also incorporated in ice cream mixes to the extent of 0.4 per cent and the whipping time of each mix carefully noted. The test mixes were made from sweet butter, skimmilk powder and water. Such a mix whipped poorly without the addition of egg yolk. The beneficial effects imparted to the whipping of such a mix varied with the different brands. The poorest product was found to contain a "filler." No one exact laboratory test was found whereby the effectiveness to produce whipping in the mix could be measured.

The effect on flavor of ice cream varied with the freshness of the egg yolk. The free fatty acid number, and the pH of the dried yolk was found to be indicative of freshness and quality. The acidity of the fat in good quality material was within the range of 2.0 to 3.5 c.c. The pH of the same samples was within the range of 6.5 to 6.7.

Fat including lipoids, in the pure products, ranged from 58 to 62.34 per cent. Moisture of fresh samples came within the range of 3.87 to 5.54 per cent. J.H.E.

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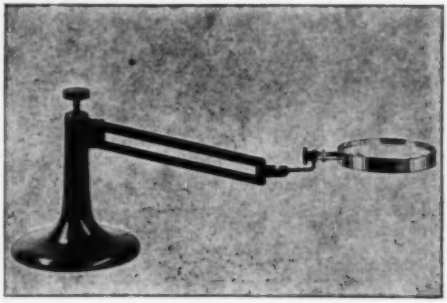

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In the Research and Development of Bacto-Peptone and Dehydrated Culture Media

DIFCO LABORATORIES

INCORPORATED

DETROIT, MICHIGAN